Photon Detection Studies and Geant3/4

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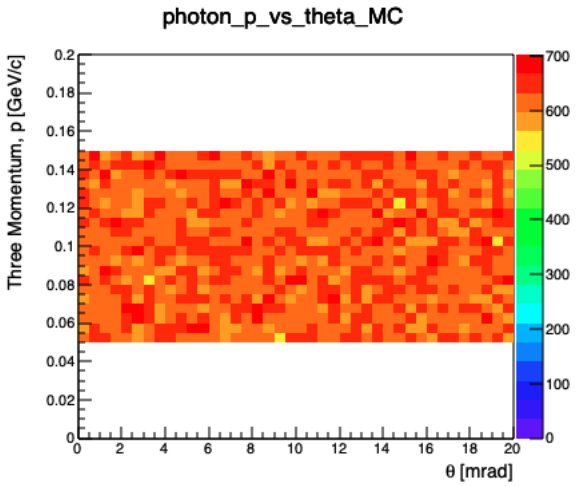
Feb. 18th, 2021

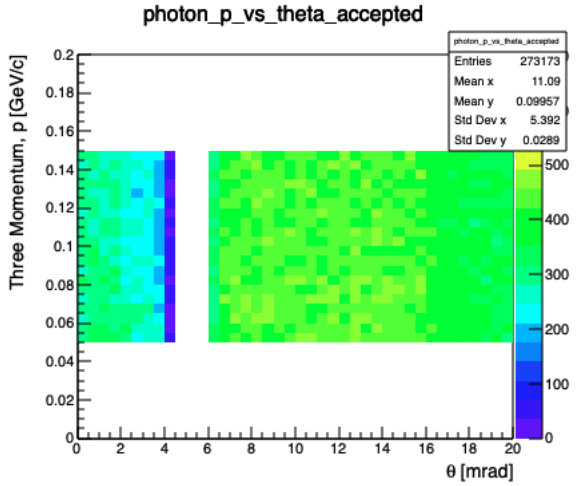
Basic Setup

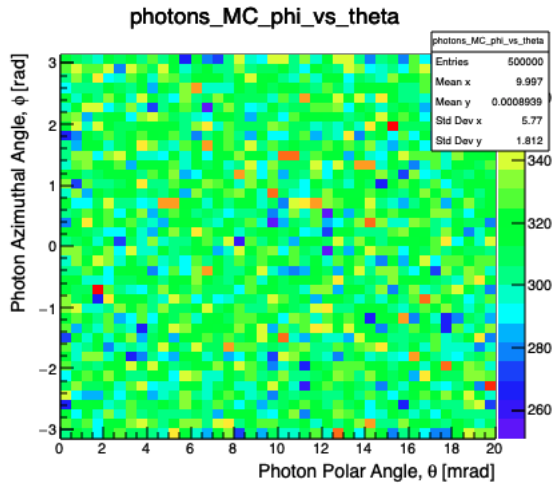
- All runs use a photon gun with 50 MeV < E_gamma < 150 MeV
  - Using 0.0 < theta < 20 mrad
  - 500k photons
- Comparisons with TGeant3 and TGeant4
- Comparisons with Al pipe and Be pipe

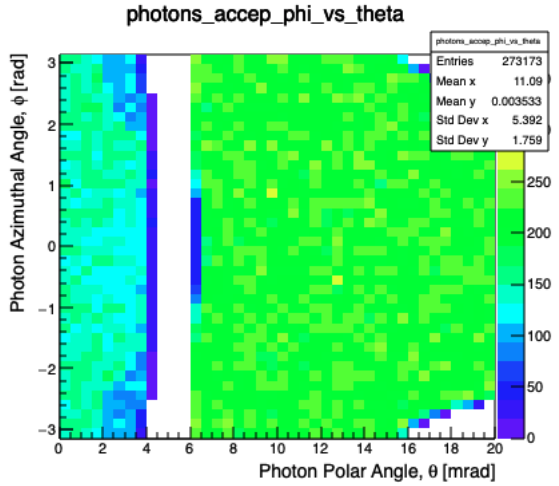
Aluminum

TGeant3 with Aluminum pipe

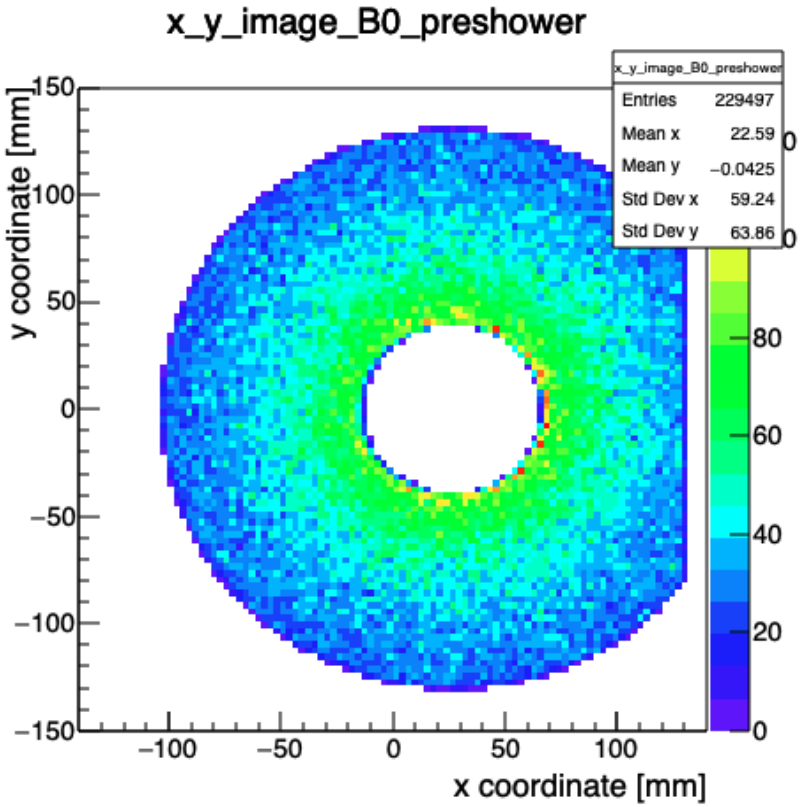


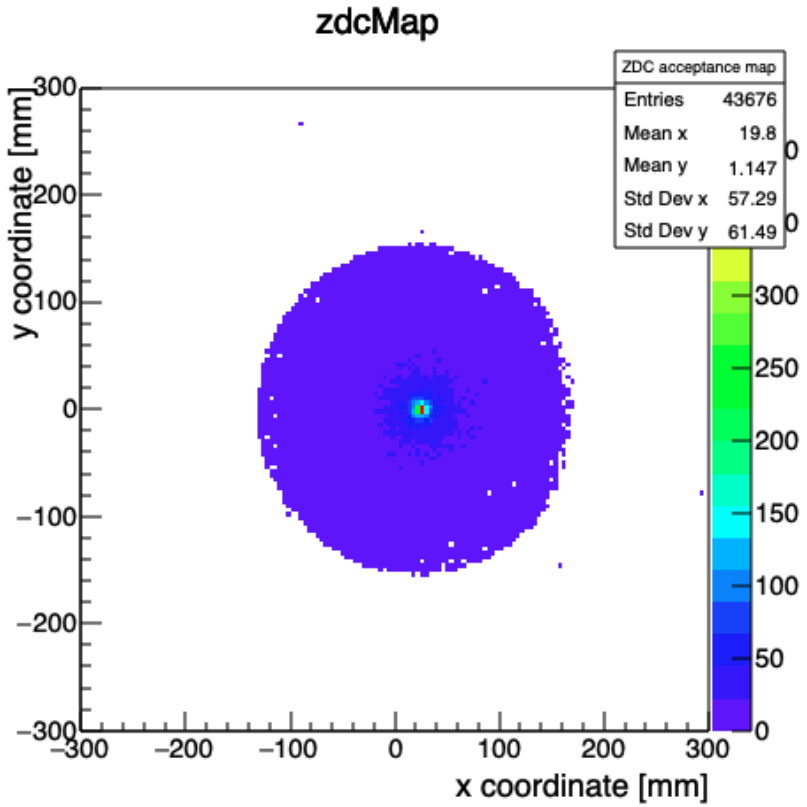






TGeant3 with Aluminum pipe





Percentage of Photons that Survive:

54.635 percent

_Aluminum beam pipe.

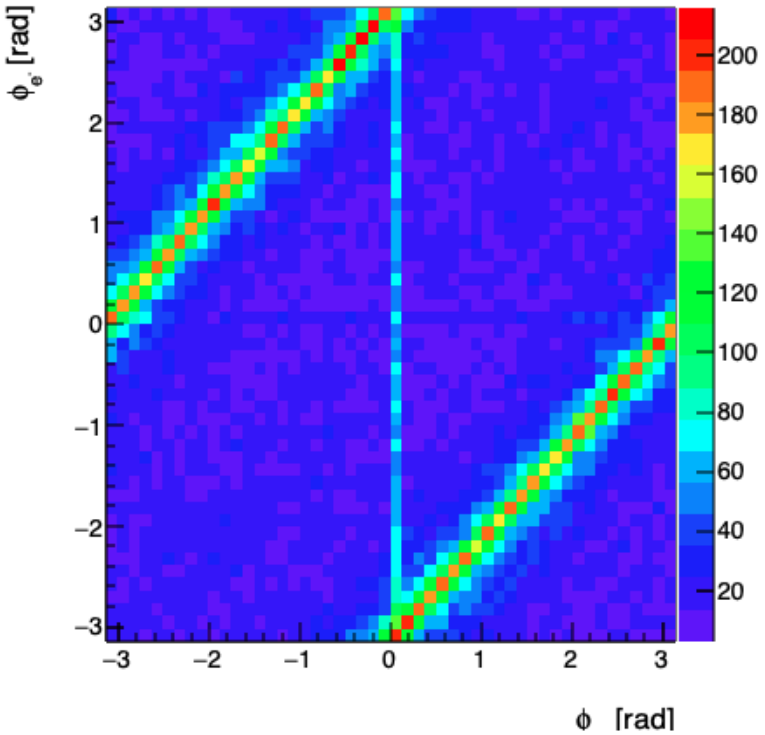
TGeant3 with Aluminum pipe

Percentage of Photons Produce Single e+e- pair:

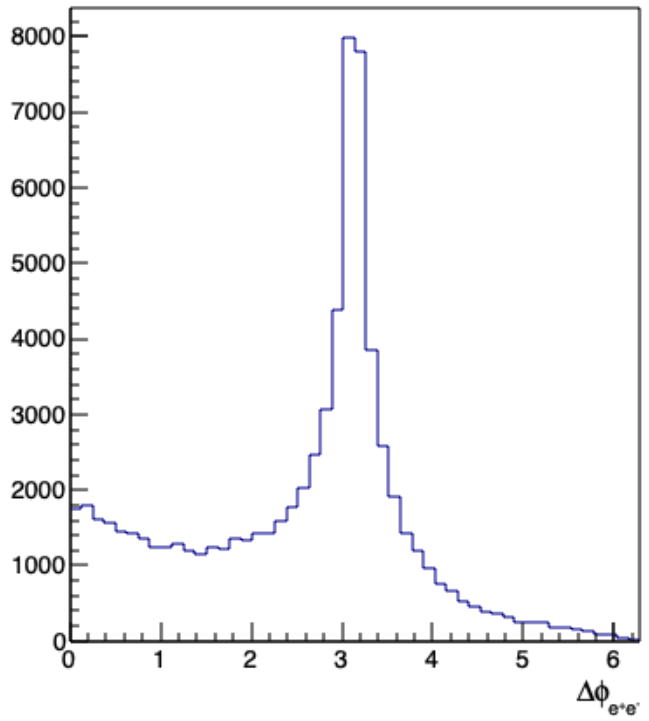
14.631 percent

_Aluminum beam pipe.

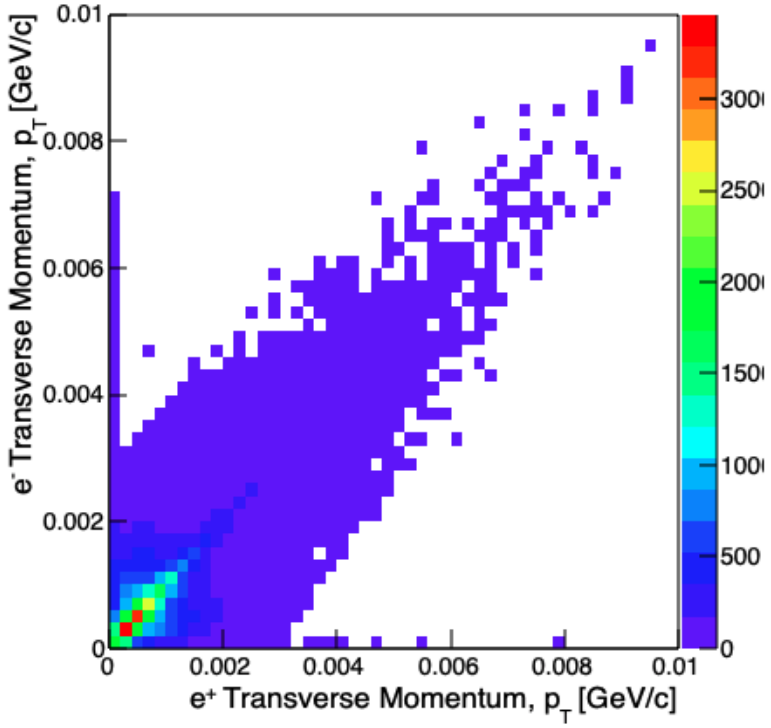
electron_phi_vs_positron_phi



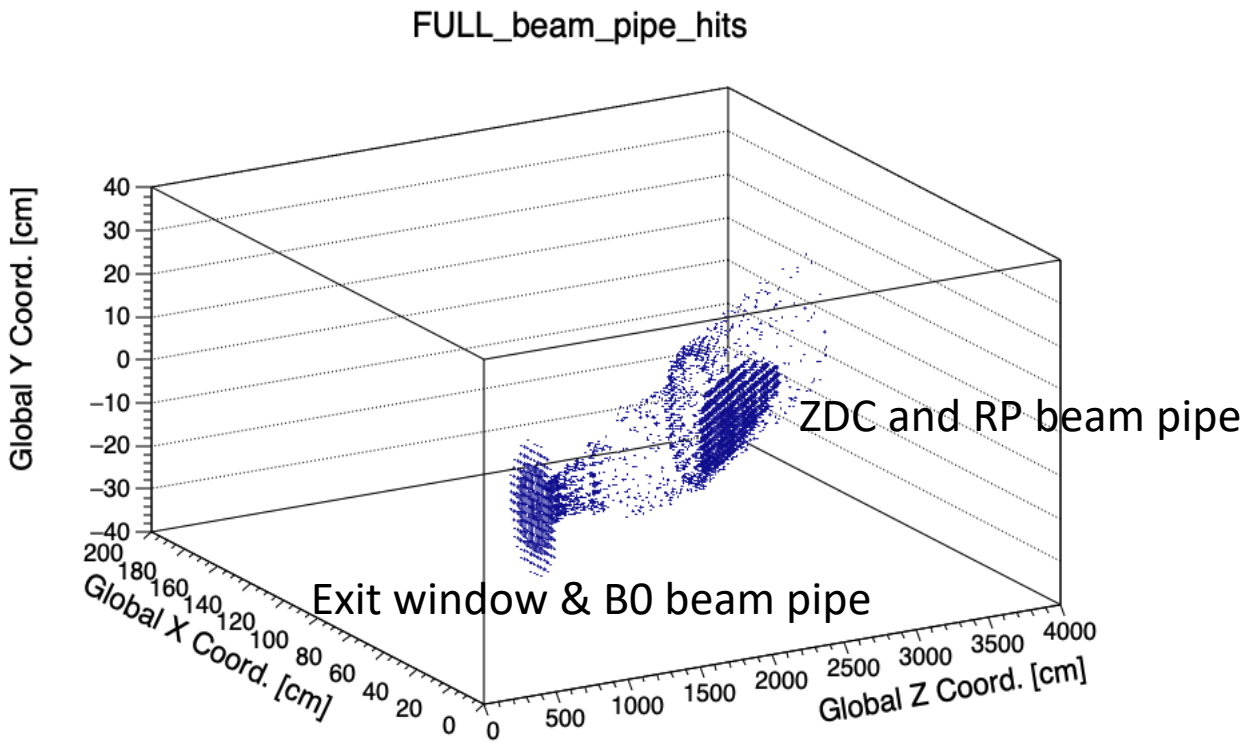
lepton_pair_delta_phi_MC

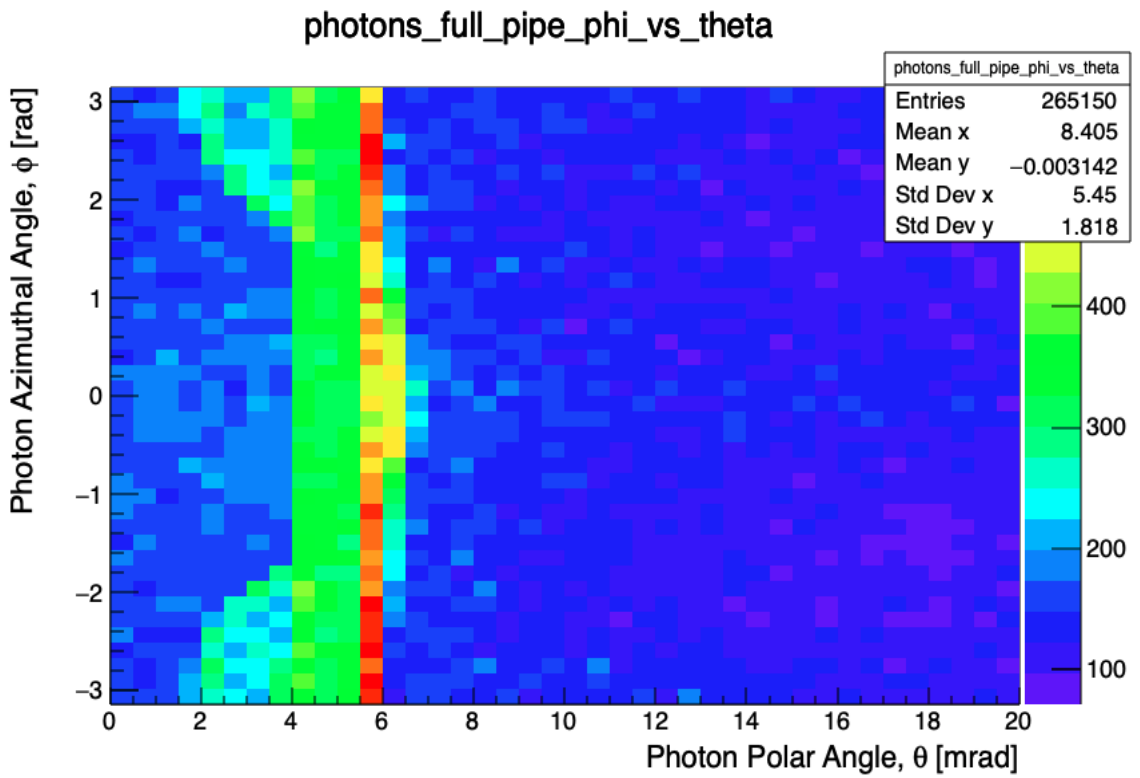


electron_pT_vs_positron_pT_MC

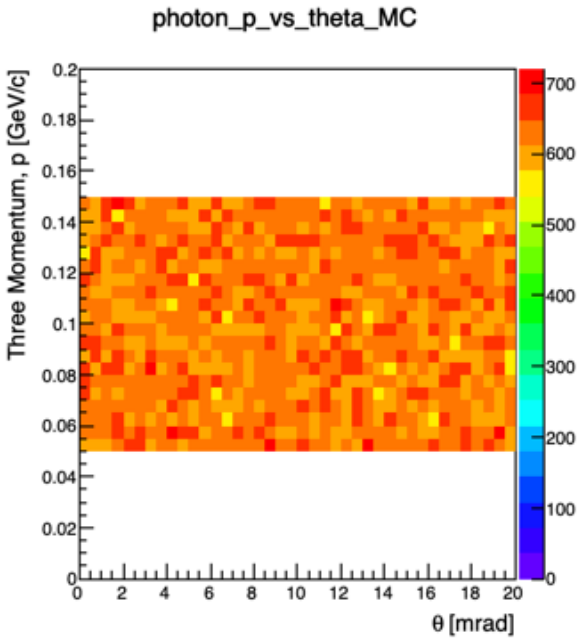


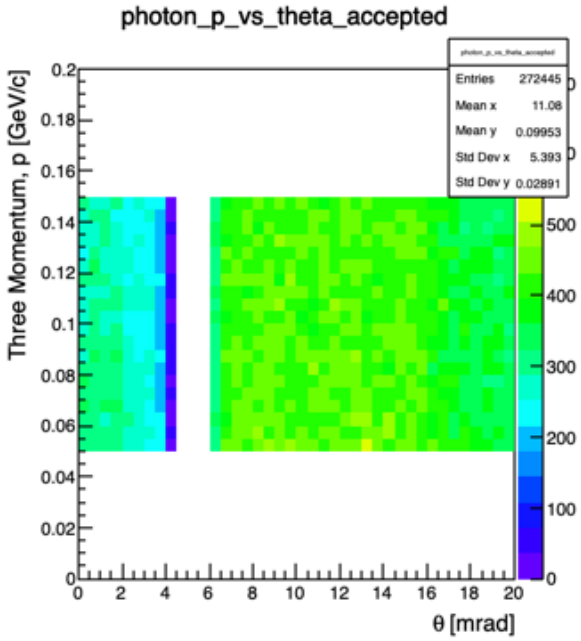
TGeant3 with Aluminum pipe

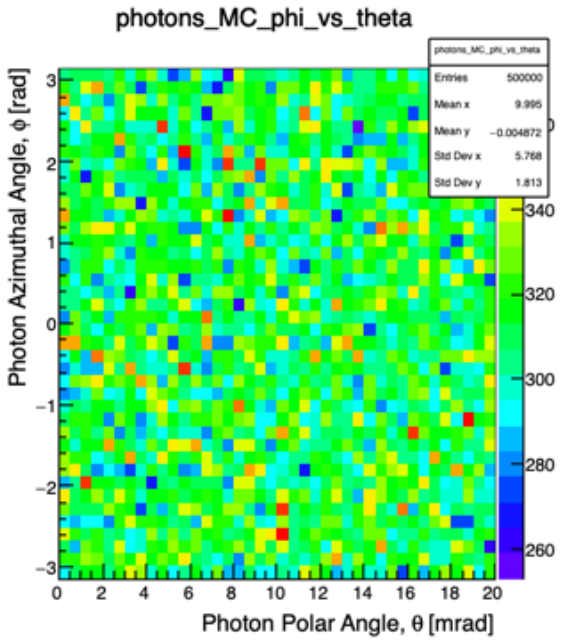


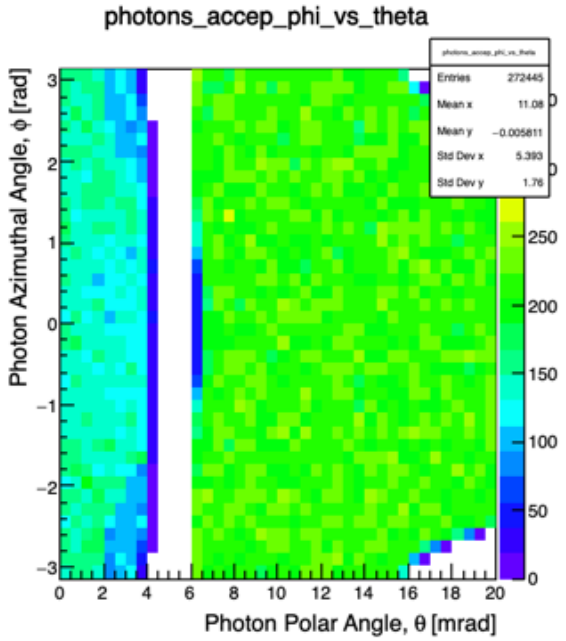


TGeant4 with Aluminum pipe

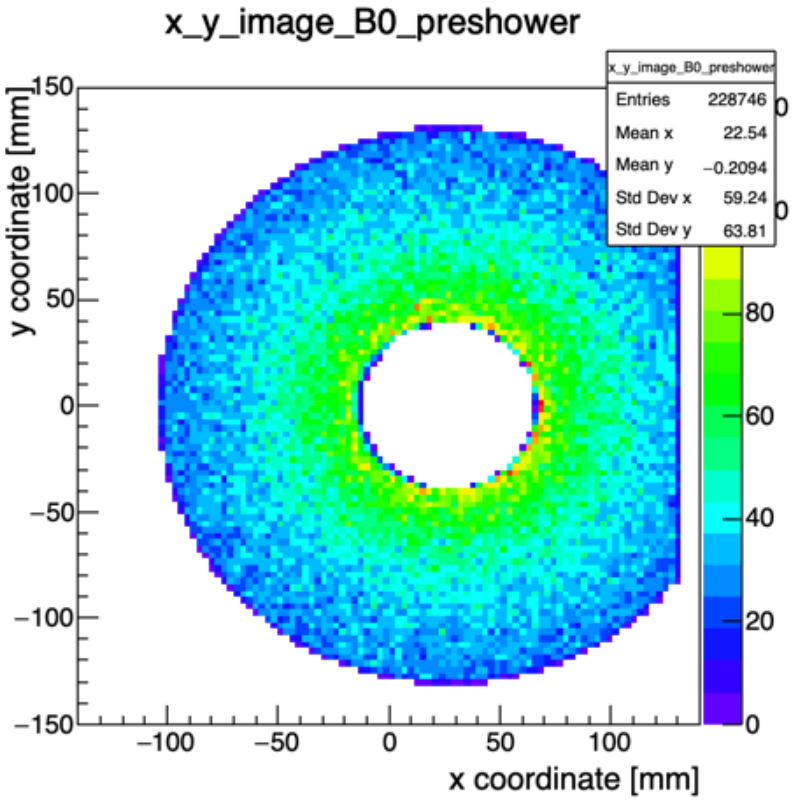


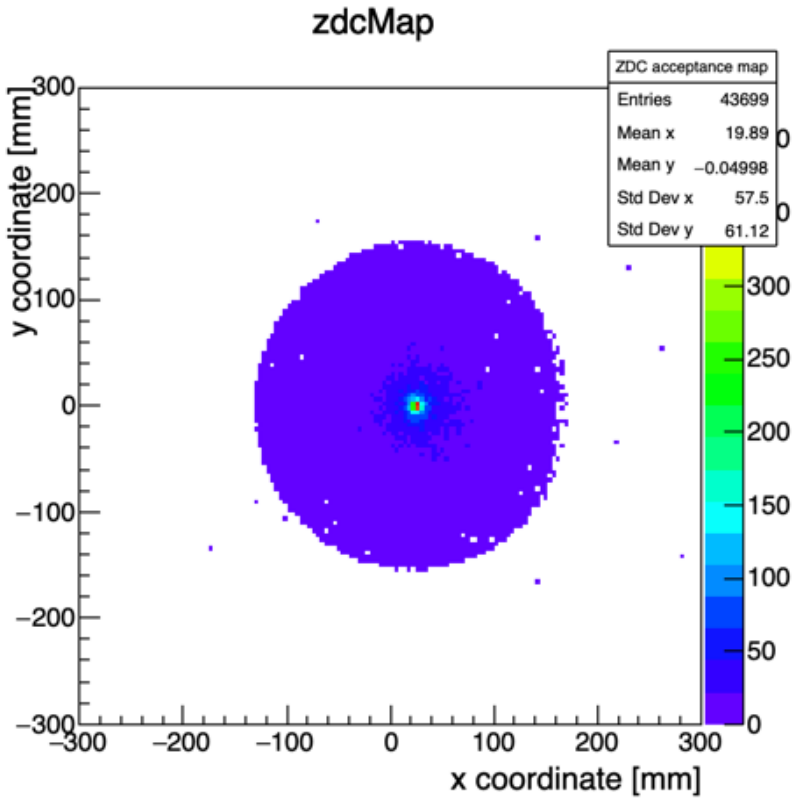






TGeant4 with Aluminum pipe





Percentage of Photons that Survive:

54.489 percent

_Aluminum beam pipe.

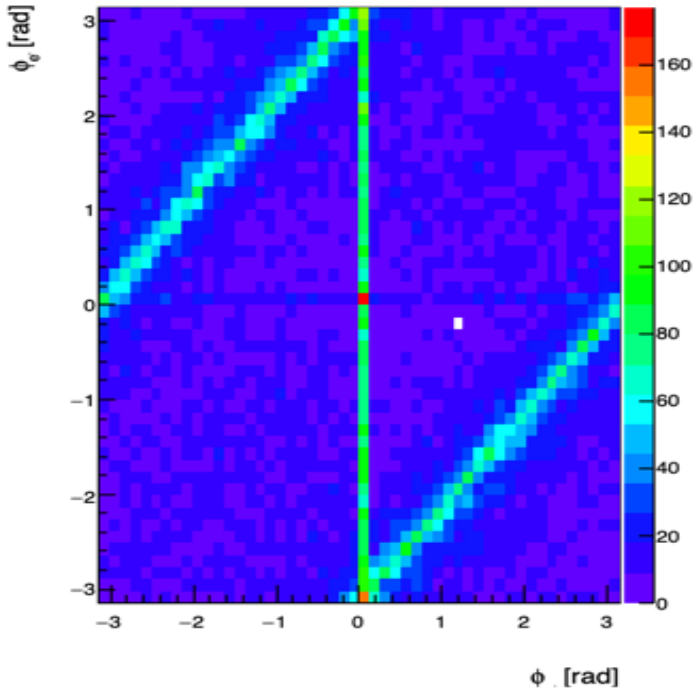
TGeant4 with Aluminum pipe

Percentage of Photons Produce Single e+e- pair:

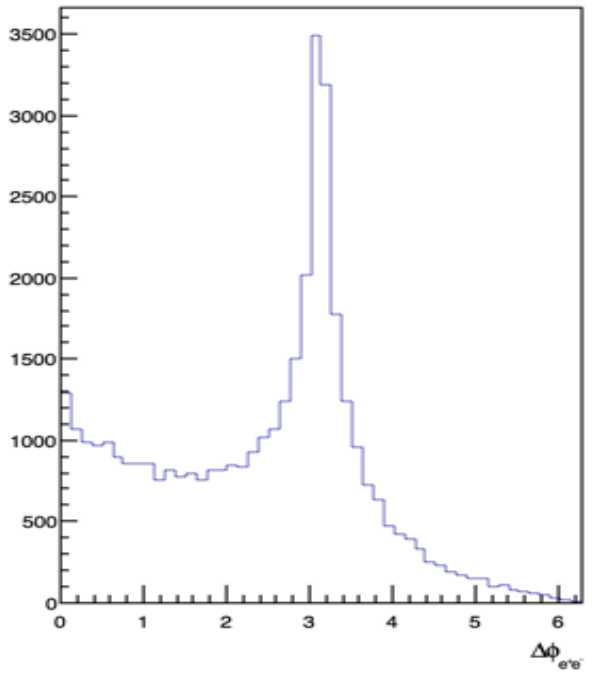
7.809 percent

_Aluminum beam pipe.

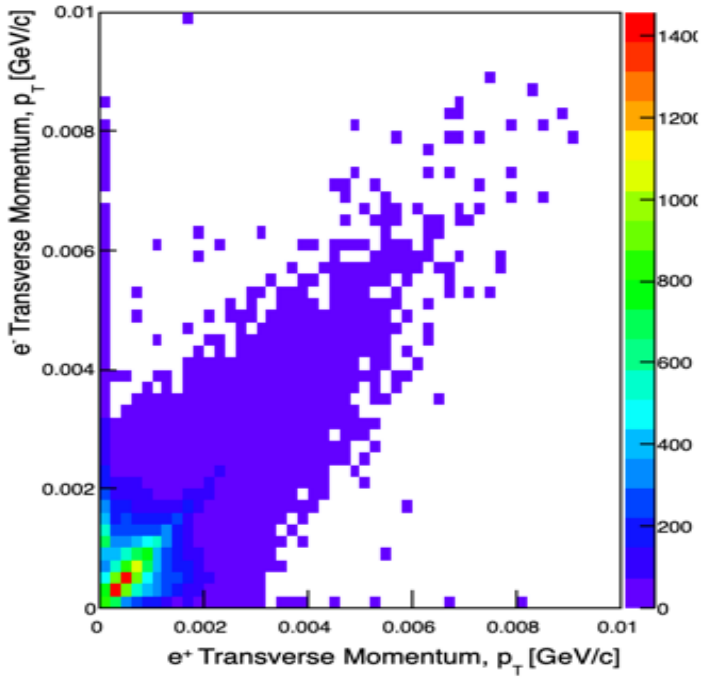
electron_phi_vs_positron_phi



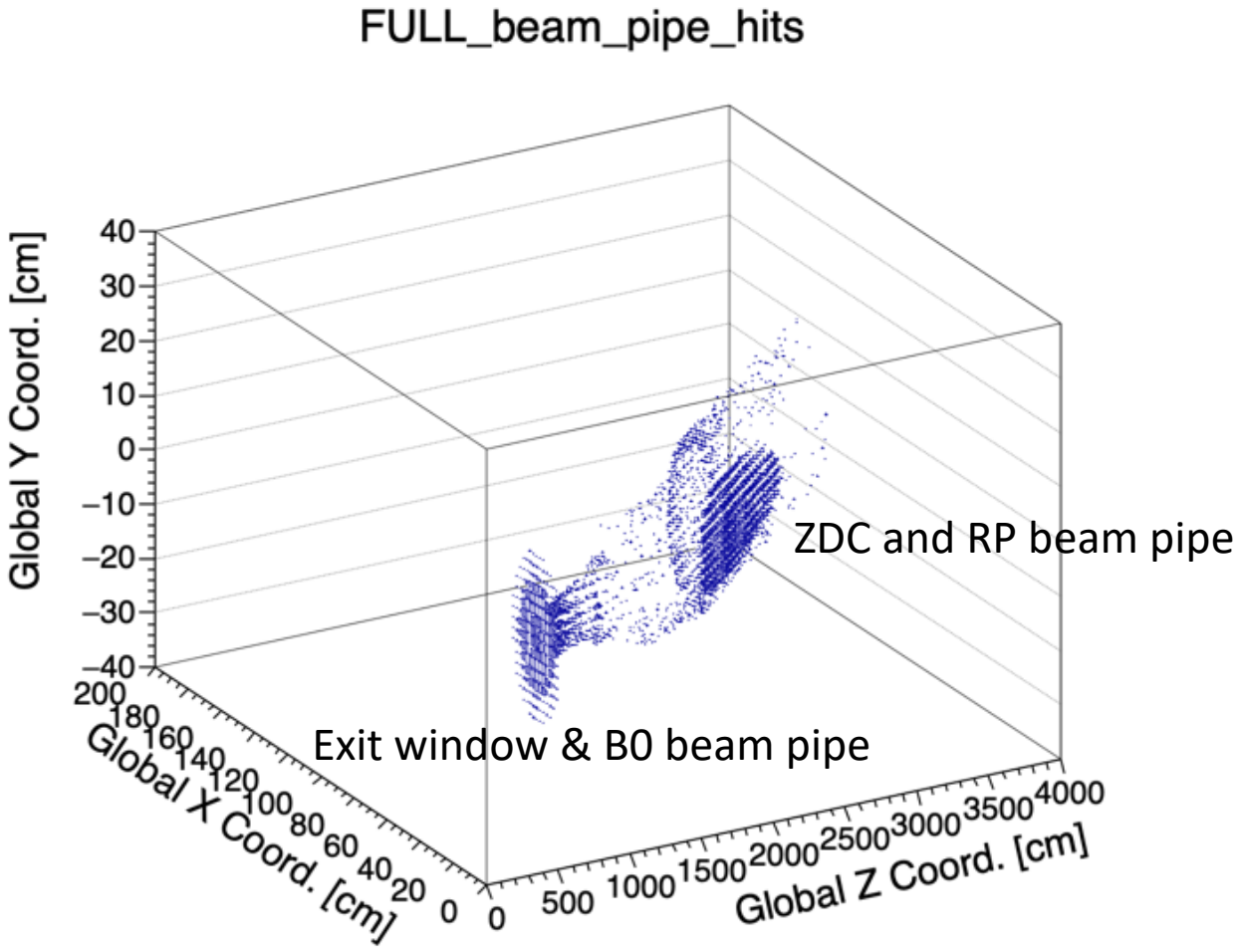
lepton_pair_delta_phi_MC

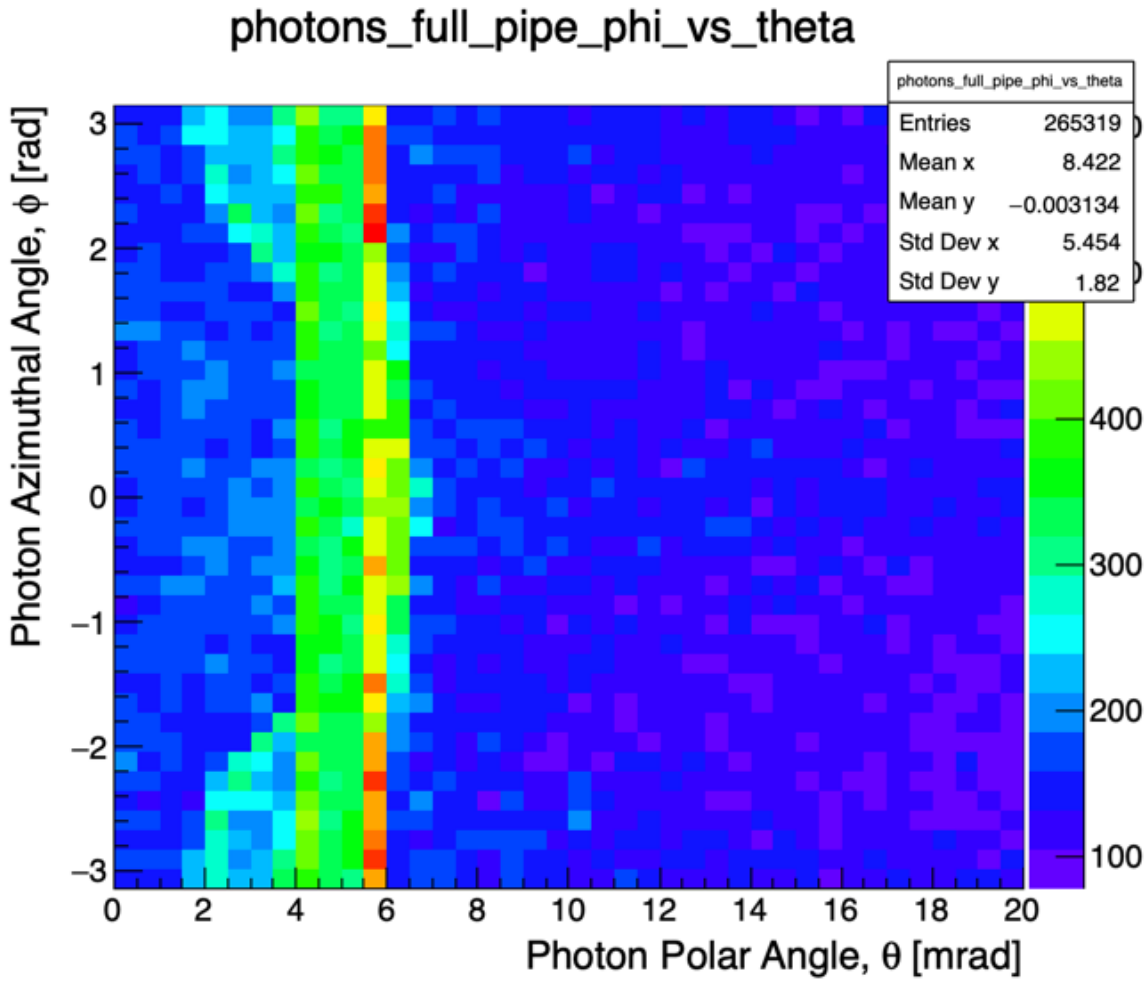


electron_pT_vs_positron_pT_MC



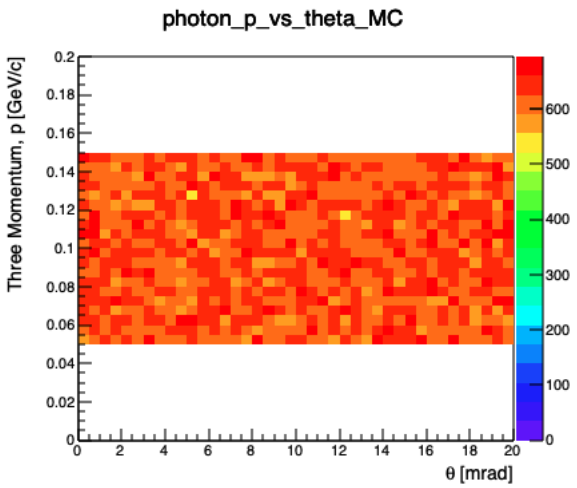
TGeant4 with Aluminum pipe

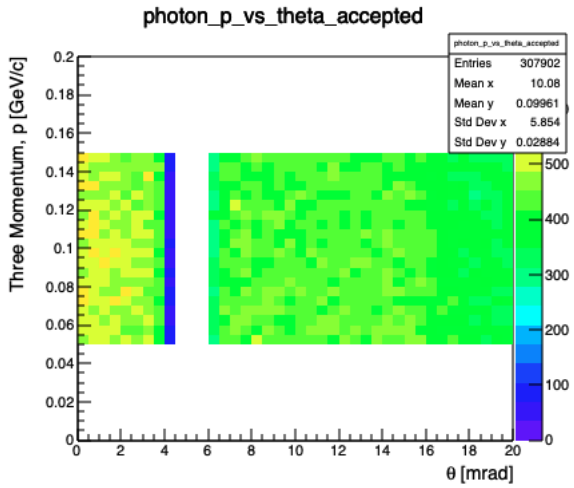


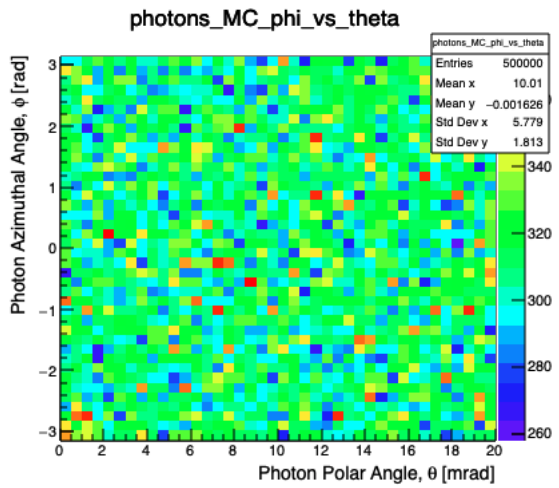


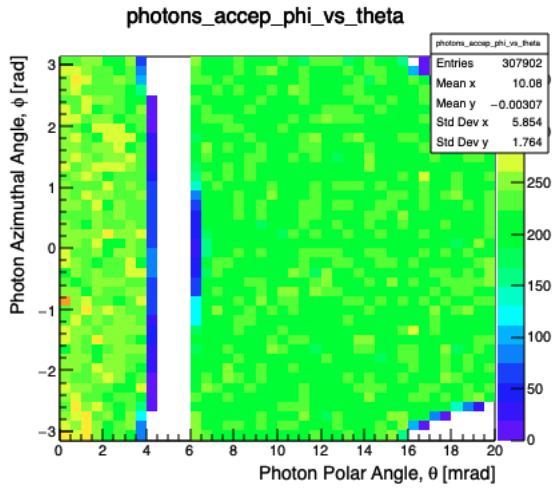
Beryllium

TGeant3 with Beryllium pipe

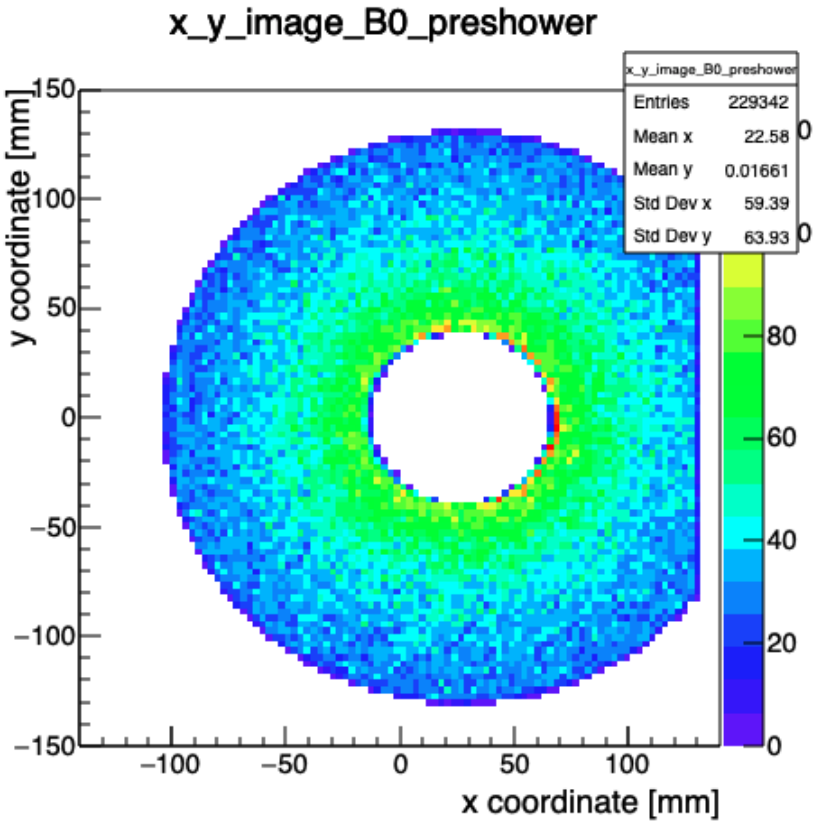


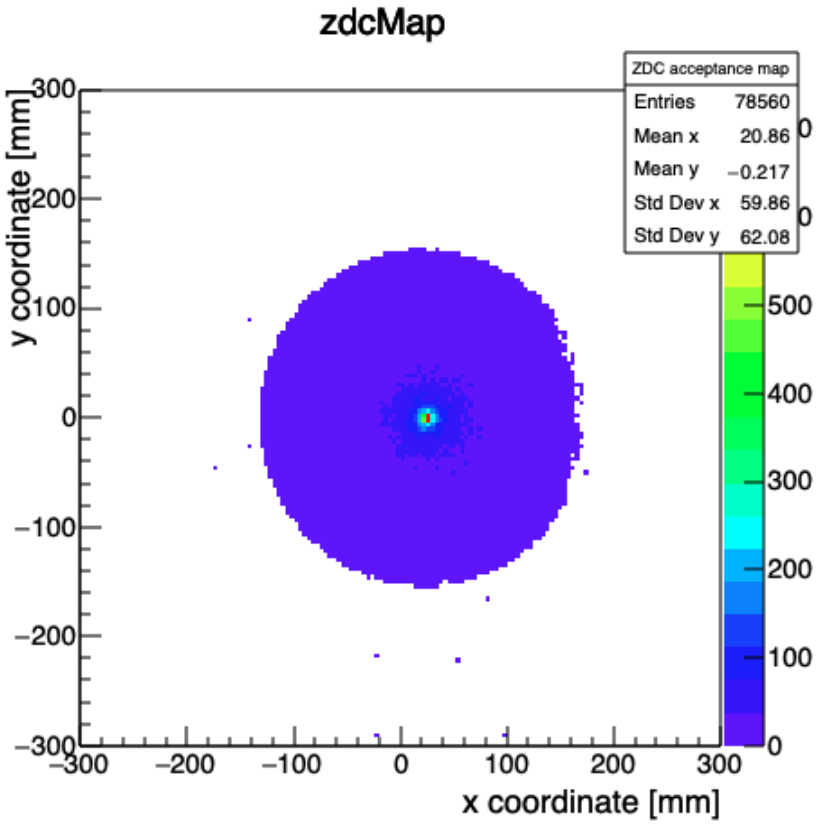






TGeant3 with Beryllium pipe





Percentage of Photons that Survive:

61.580 percent

_Beryllium beam pipe.

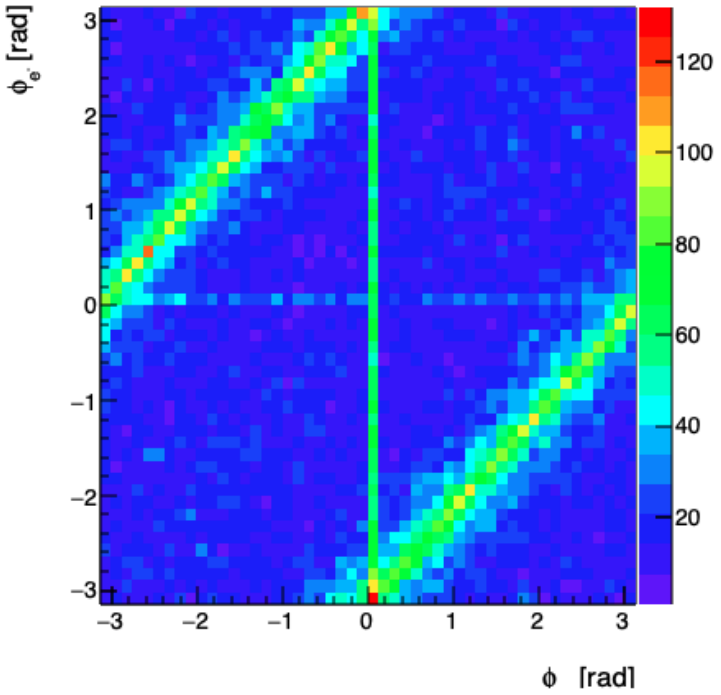
TGeant3 with Beryllium pipe

Percentage of Photons Produce Single e+e- pair:

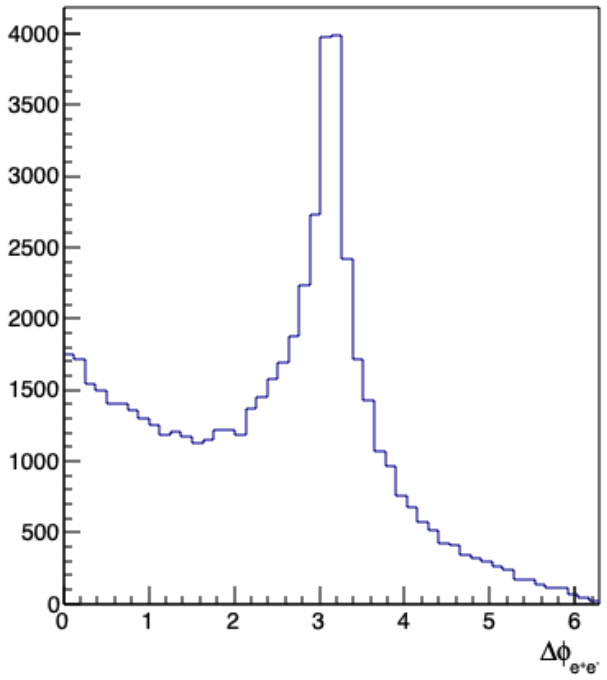
11.367 percent

_Beryllium beam pipe.

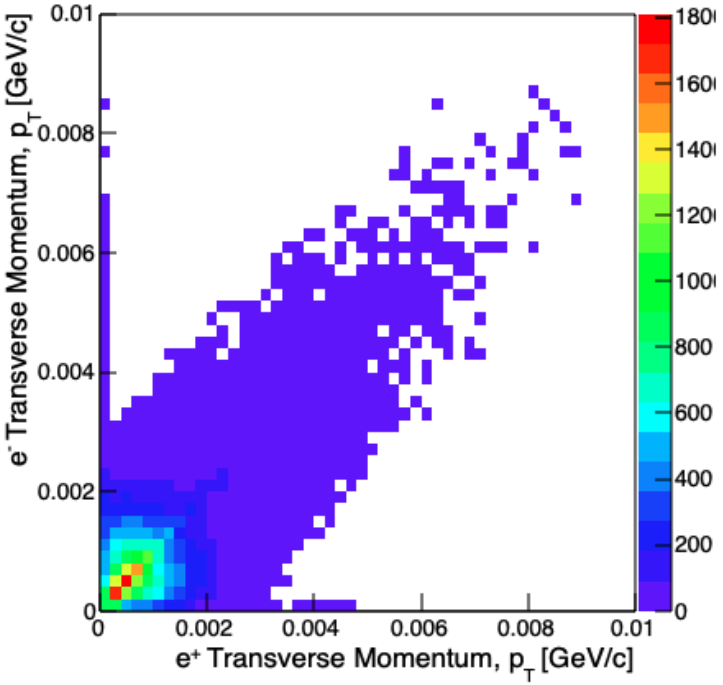
electron_phi_vs_positron_phi



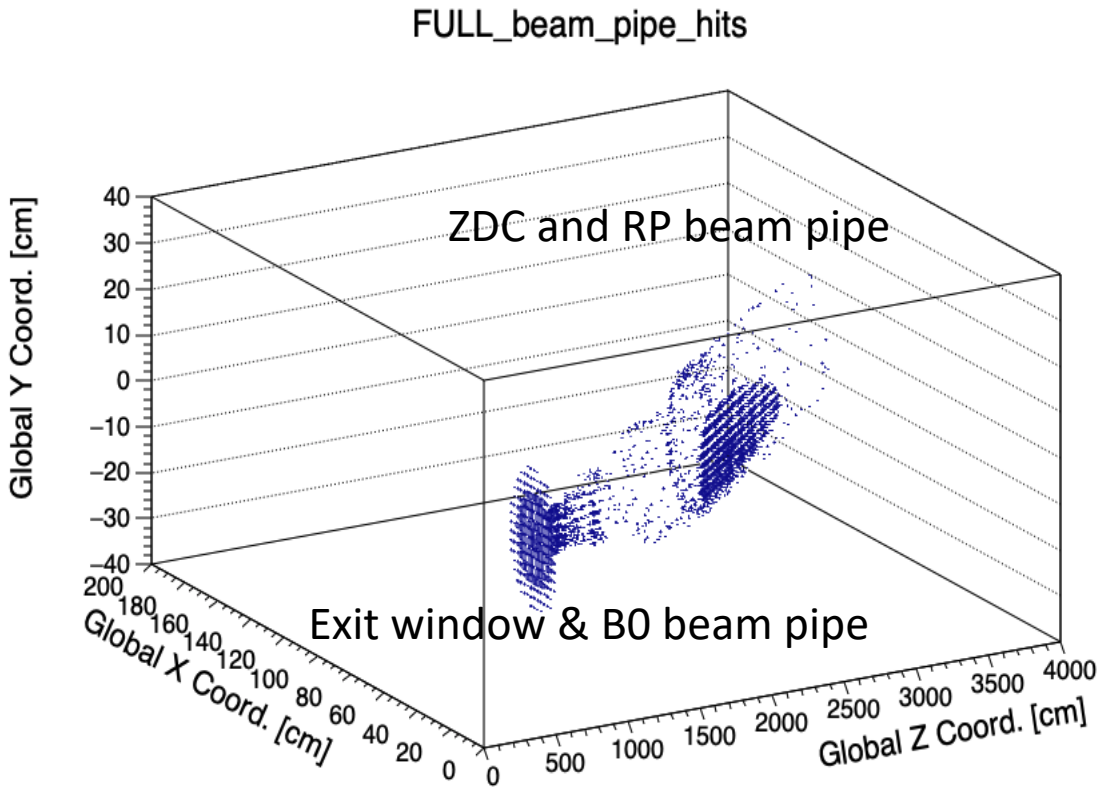
lepton_pair_delta_phi_MC

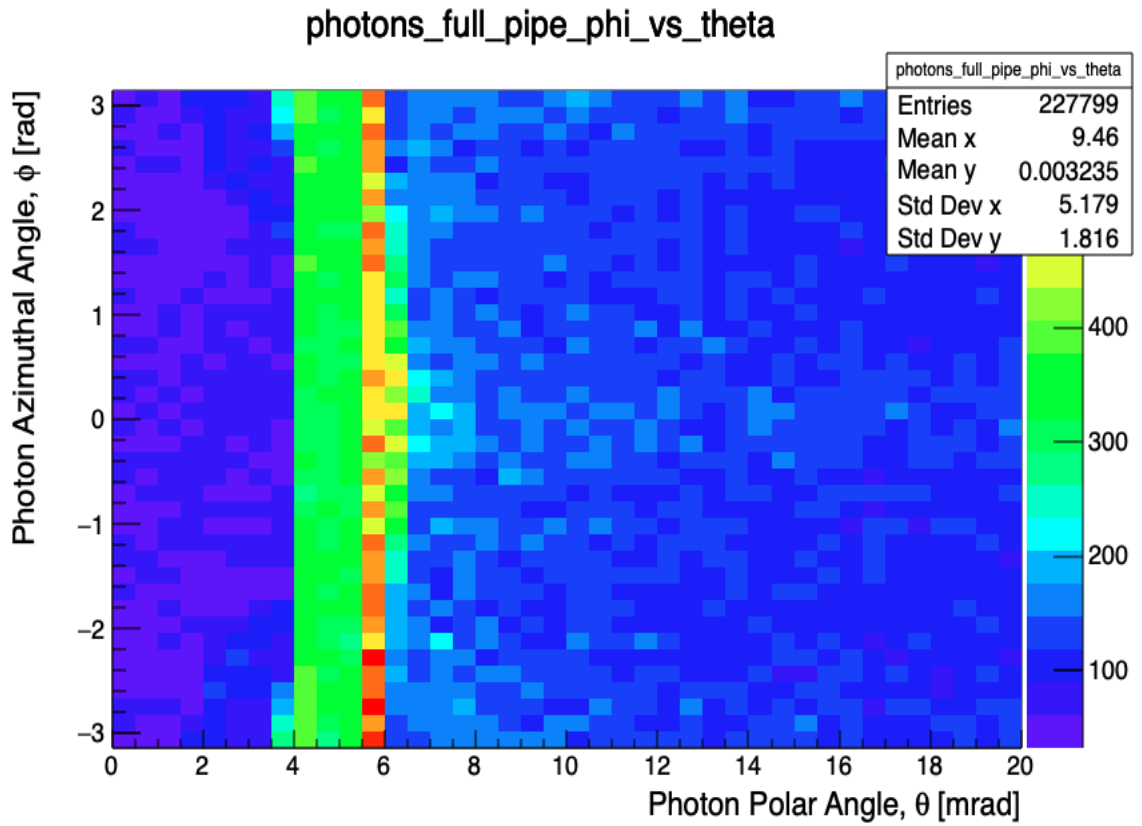


electron_pT_vs_positron_pT_MC

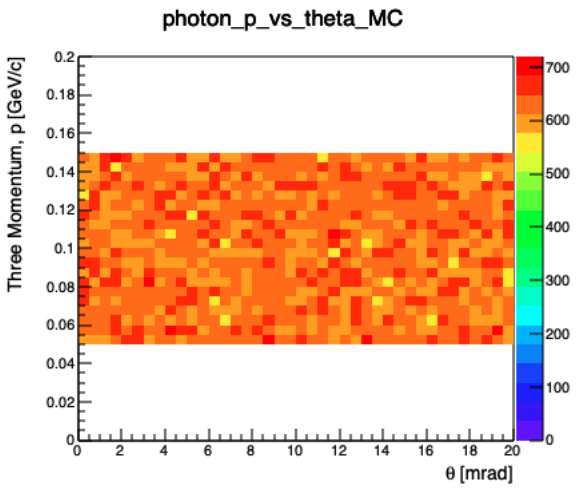


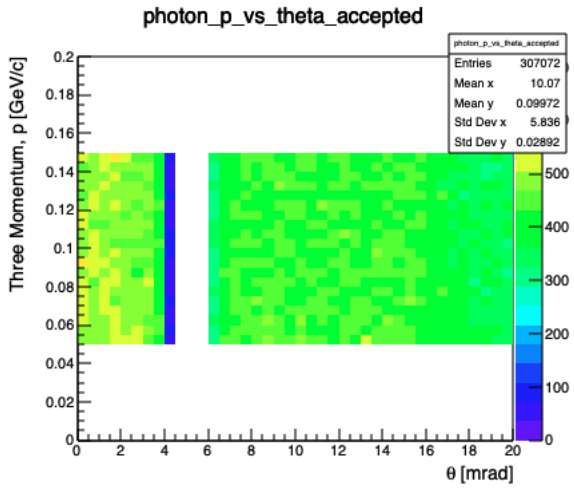
TGeant3 with Beryllium pipe

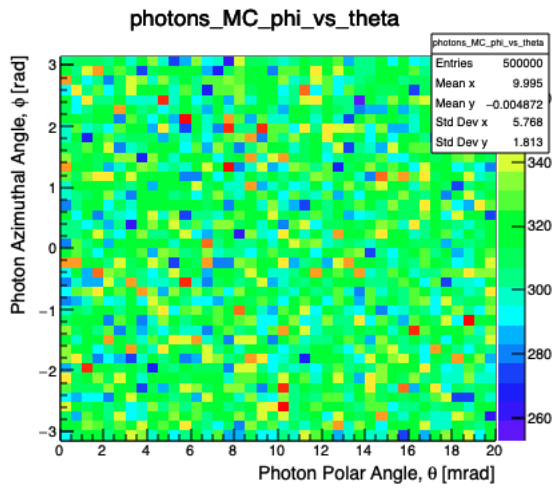


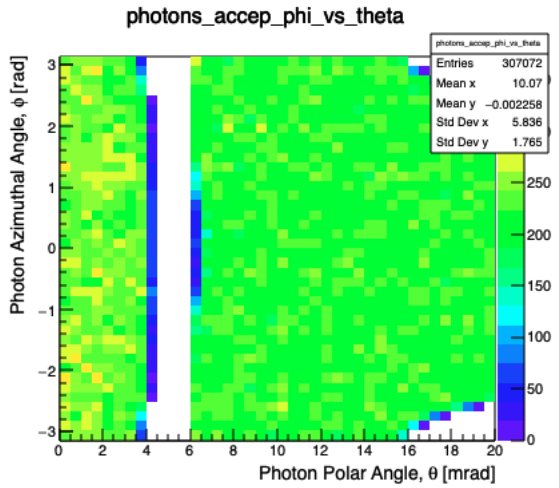


TGeant4 with Beryllium pipe

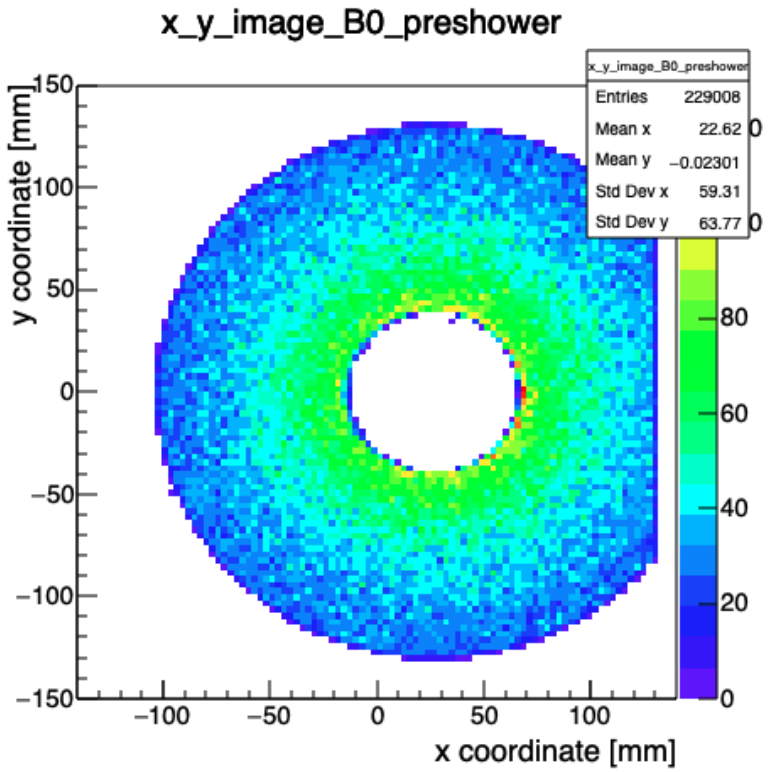


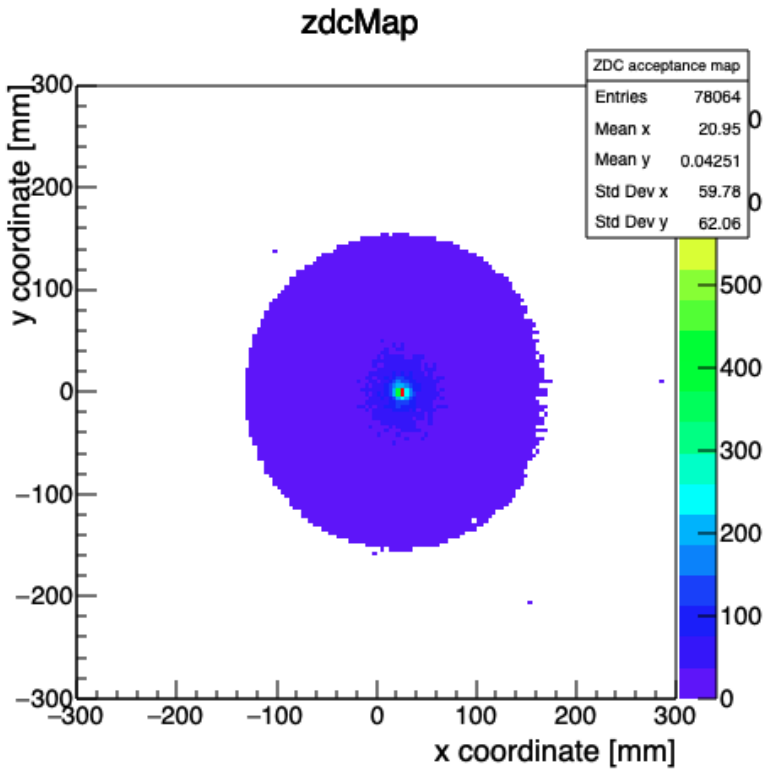






TGeant4 with Beryllium pipe





Percentage of Photons that Survive:

61.414 percent

_Beryllium beam pipe.

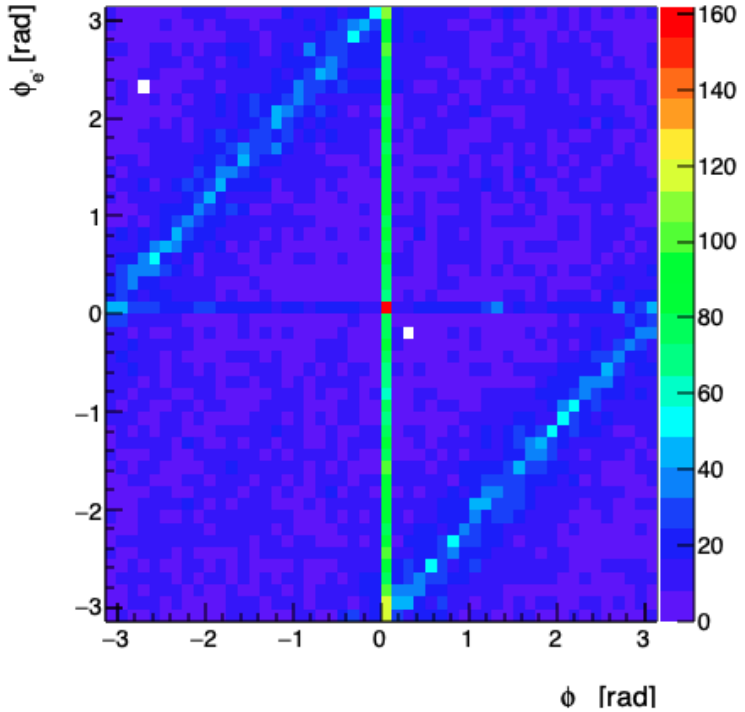
TGeant4 with Beryllium pipe

Percentage of Photons Produce Single e+e- pair:

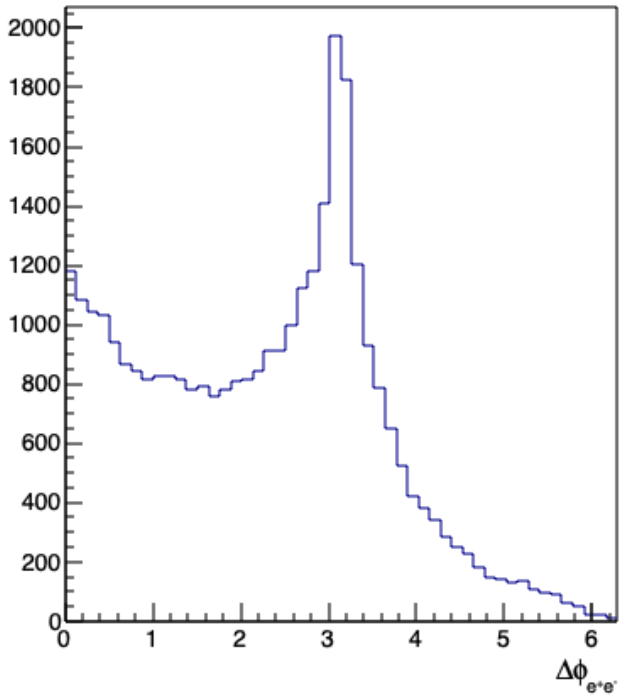
6.676 percent

_Beryllium beam pipe.

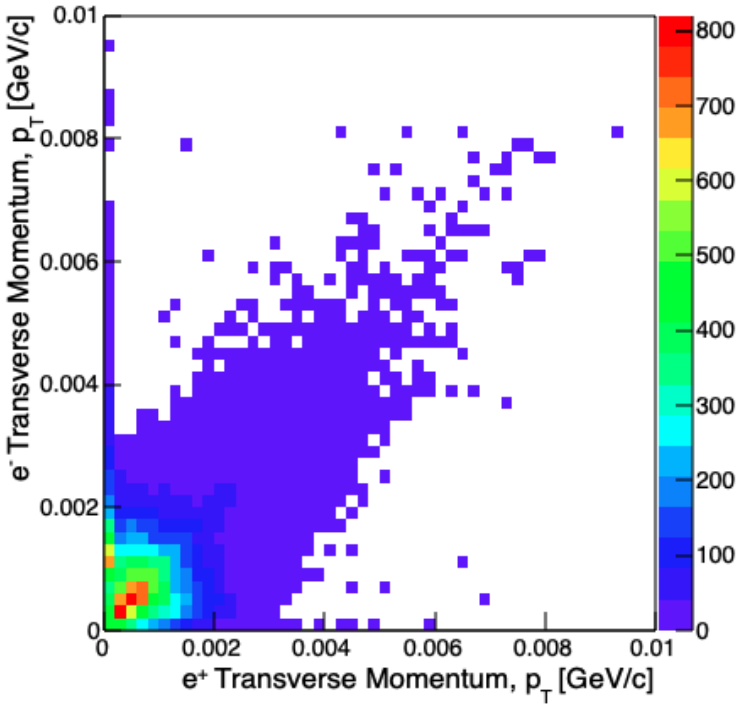
electron_phi_vs_positron_phi



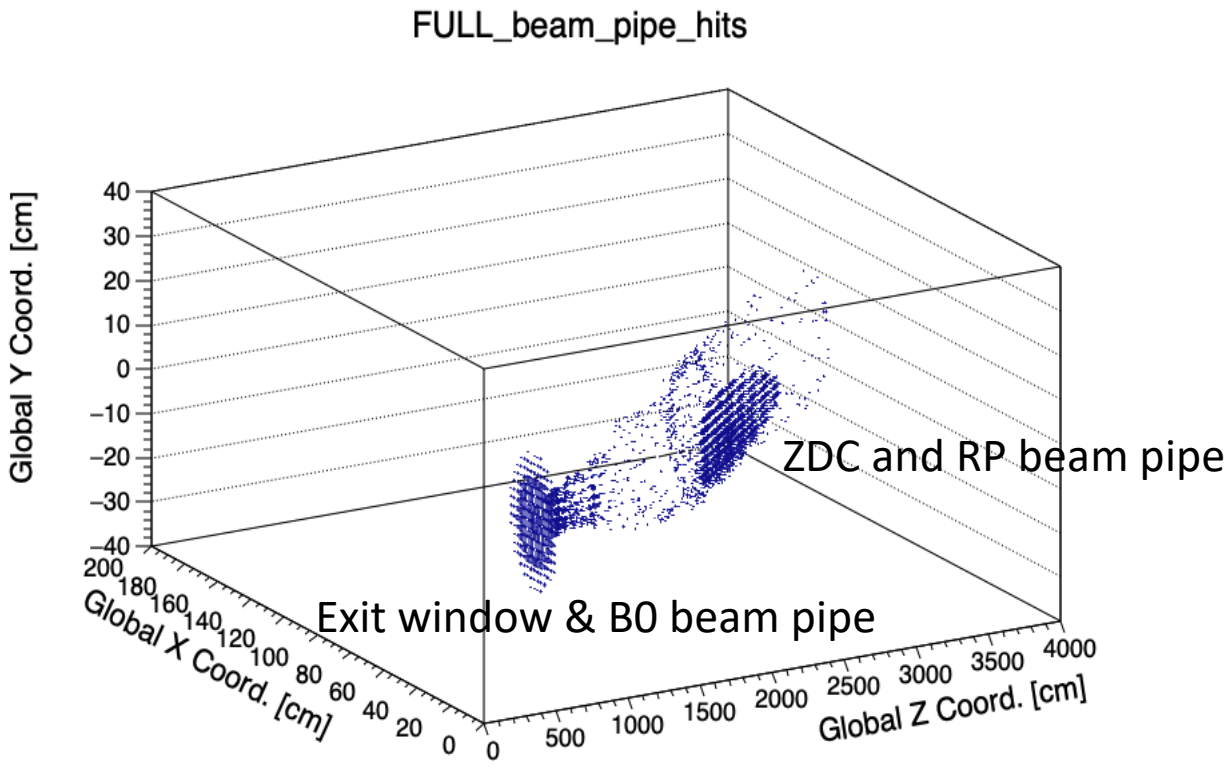
lepton_pair_delta_phi_MC

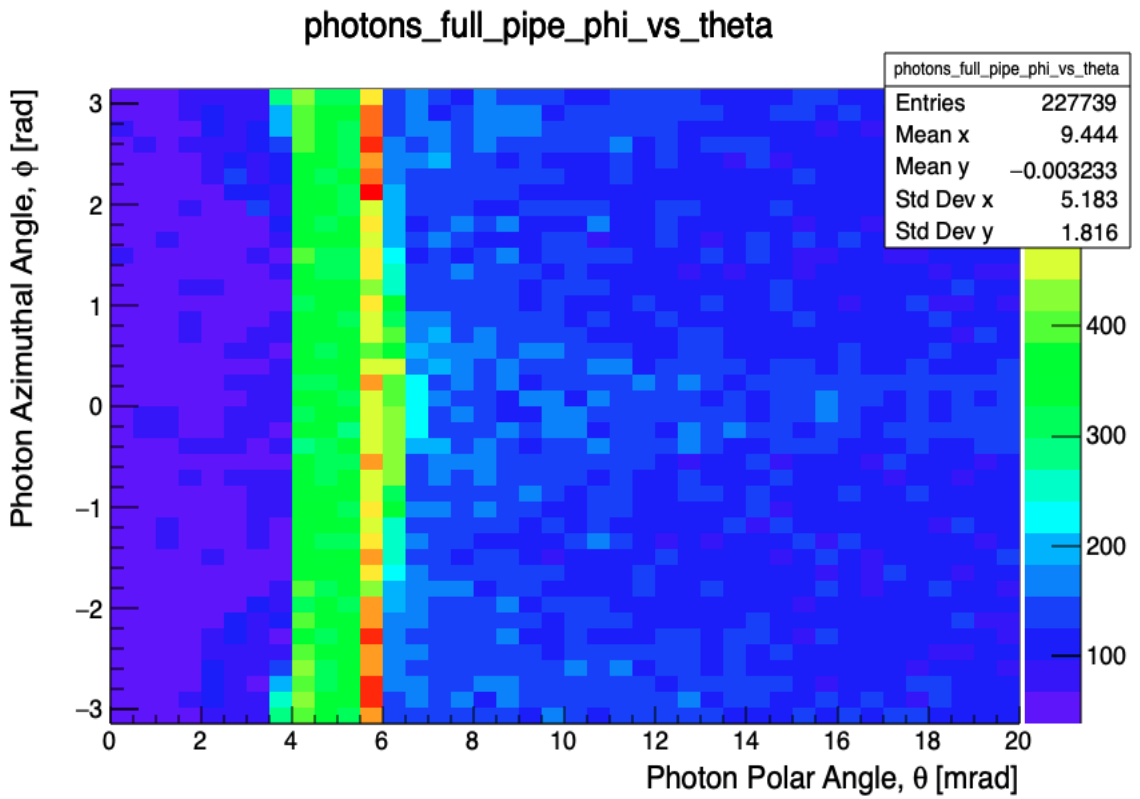


electron_pT_vs_positron_pT_MC



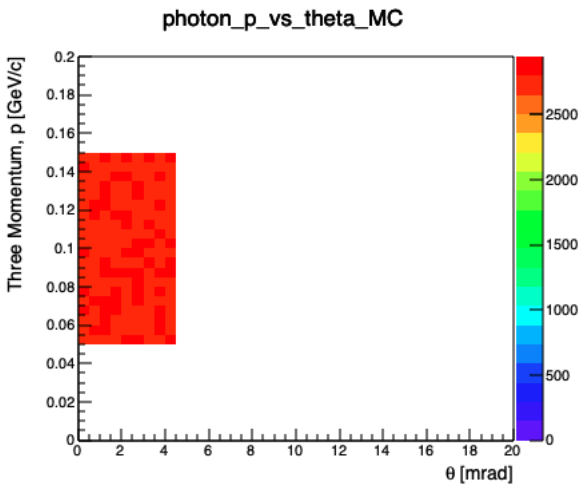
TGeant4 with Beryllium pipe

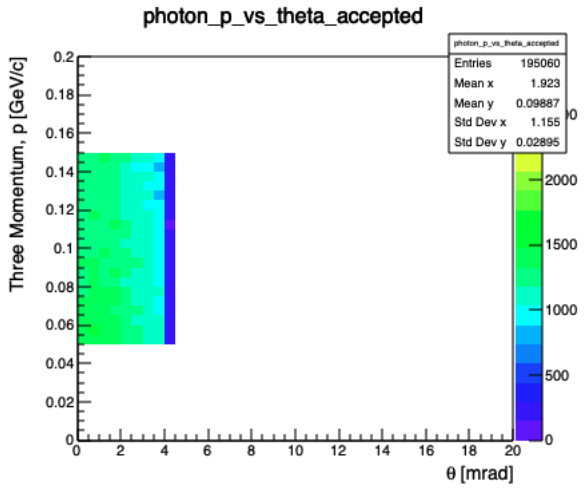


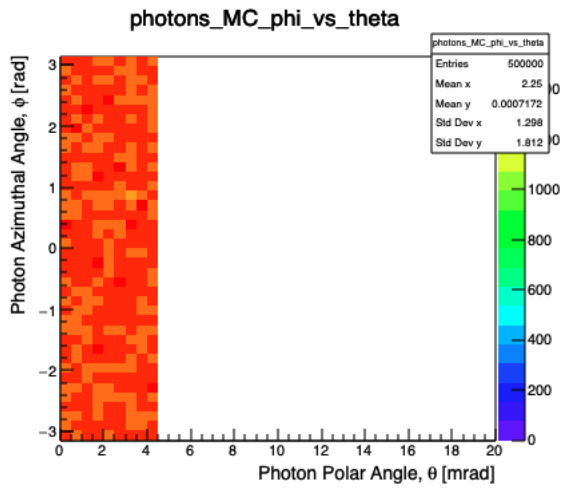


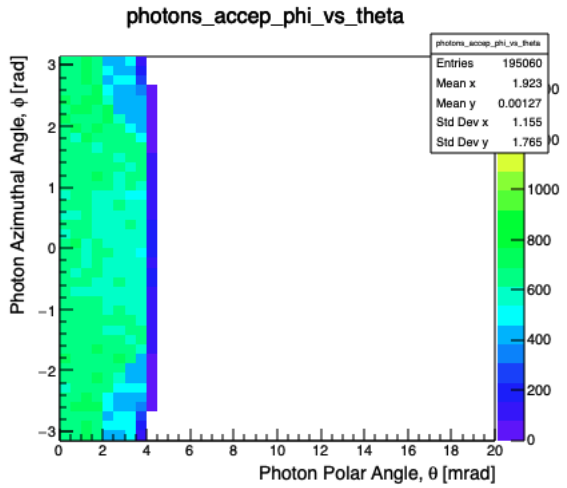
Cone Limited to 4.5 mrad

TGeant3 with Aluminum Pipe

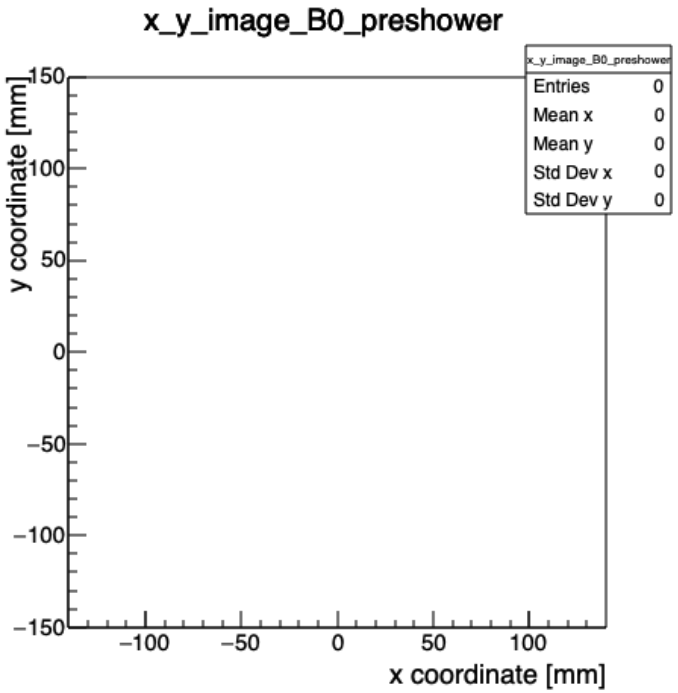


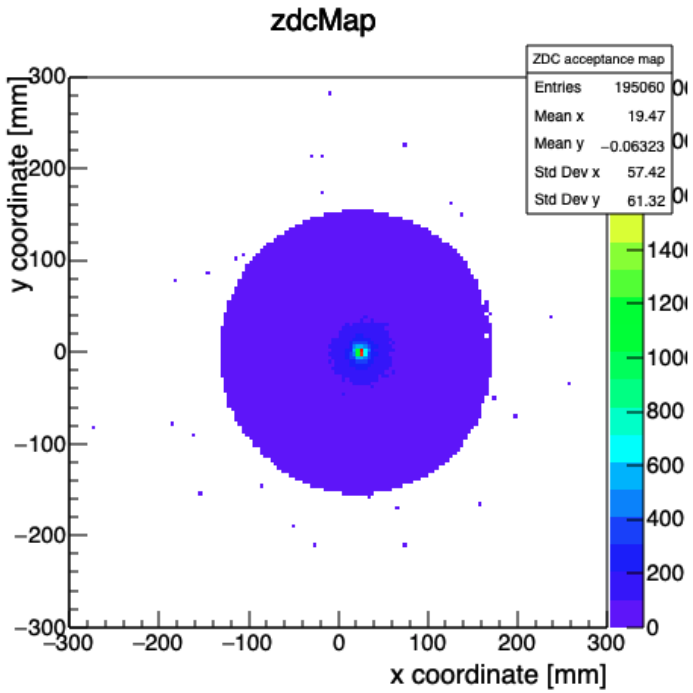






TGeant3 with Aluminum Pipe





Percentage of Photons that Survive:

39.012 percent

_Aluminum beam pipe.

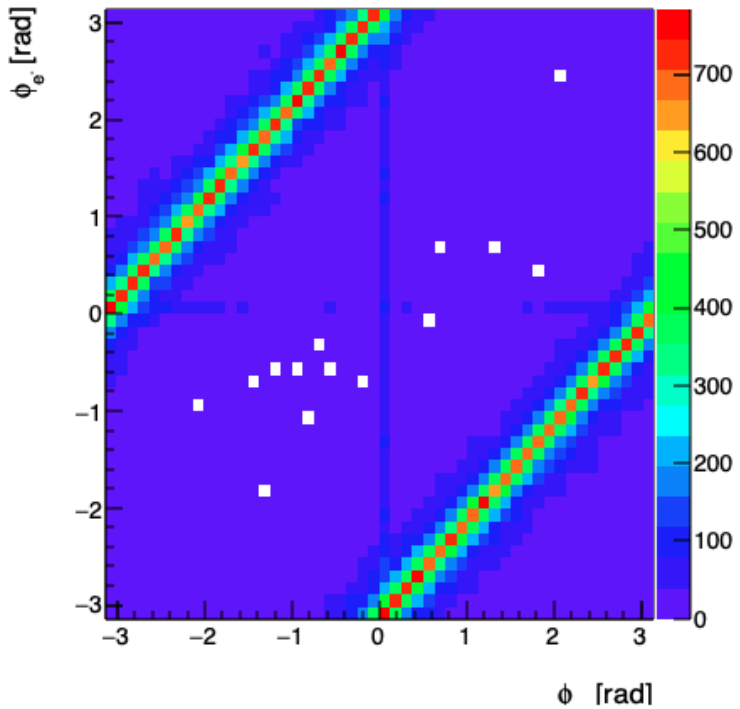
TGeant3 with Aluminum Pipe

Percentage of Photons Produce Single e+e- pair:

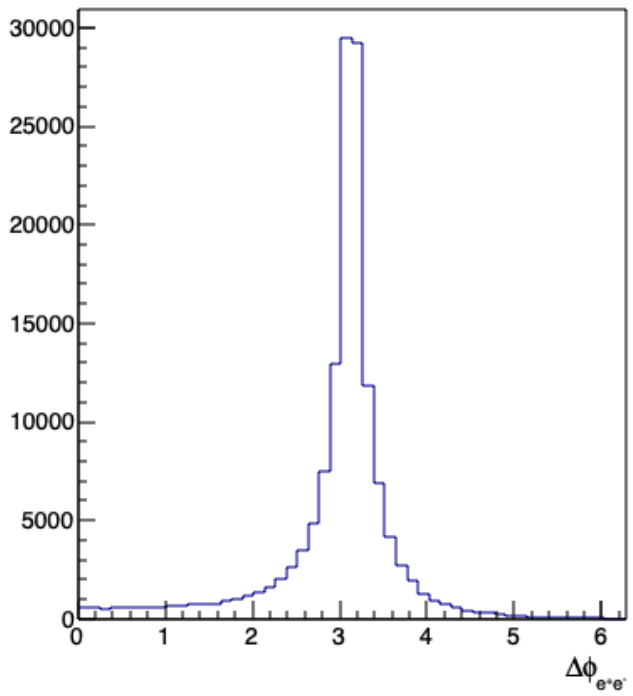
27.861 percent

_Aluminum beam pipe.

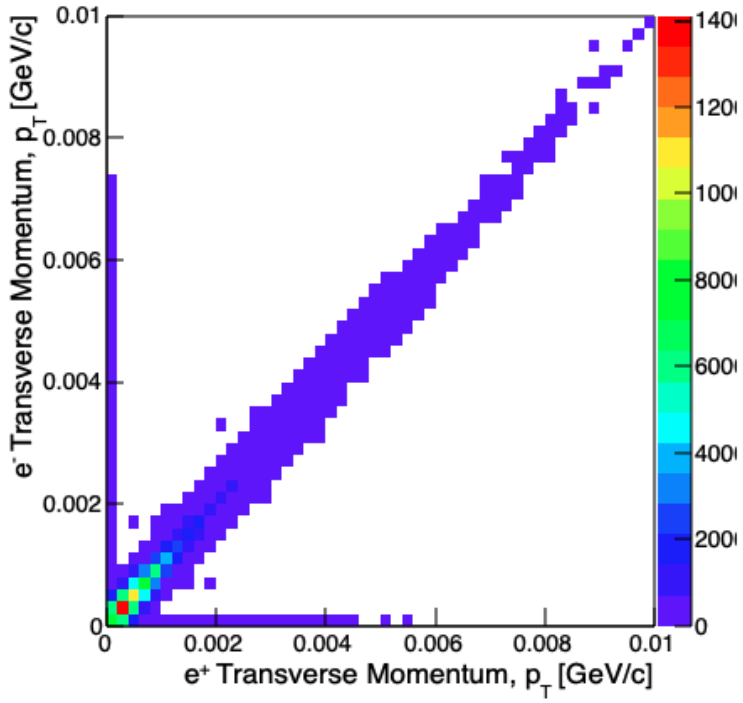
electron_phi_vs_positron_phi



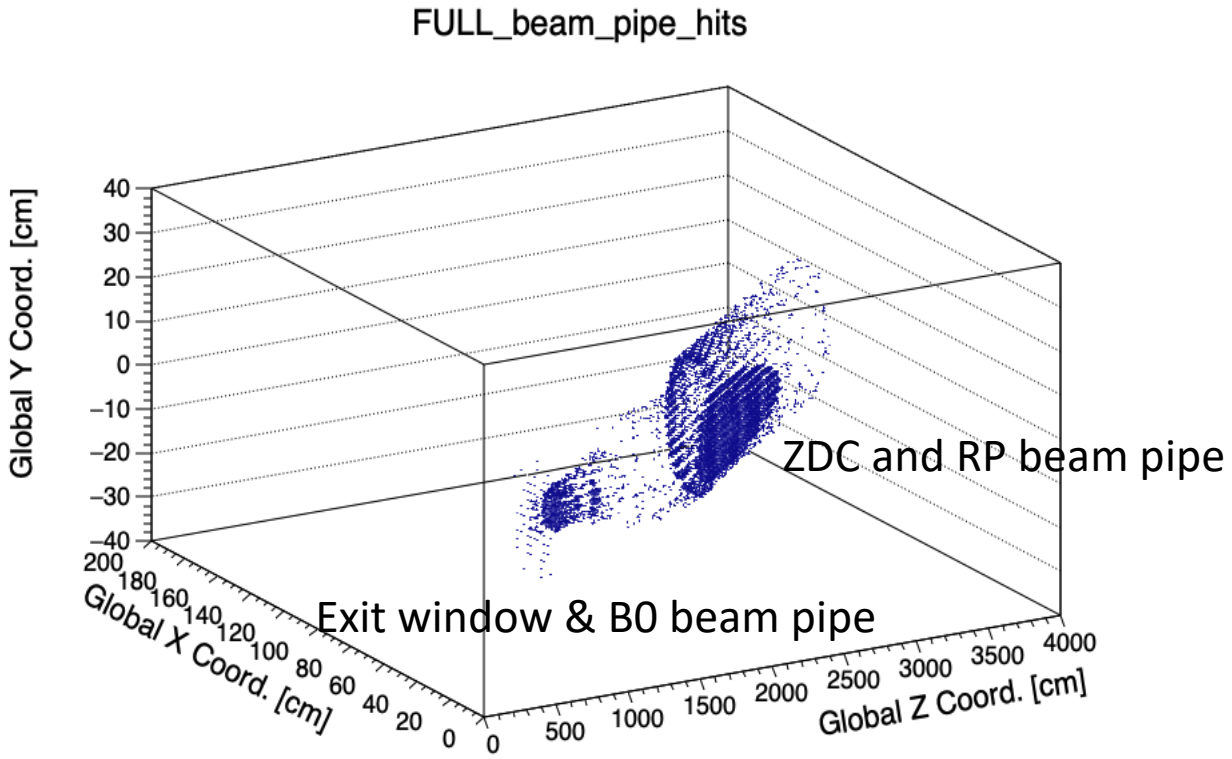
lepton_pair_delta_phi_MC

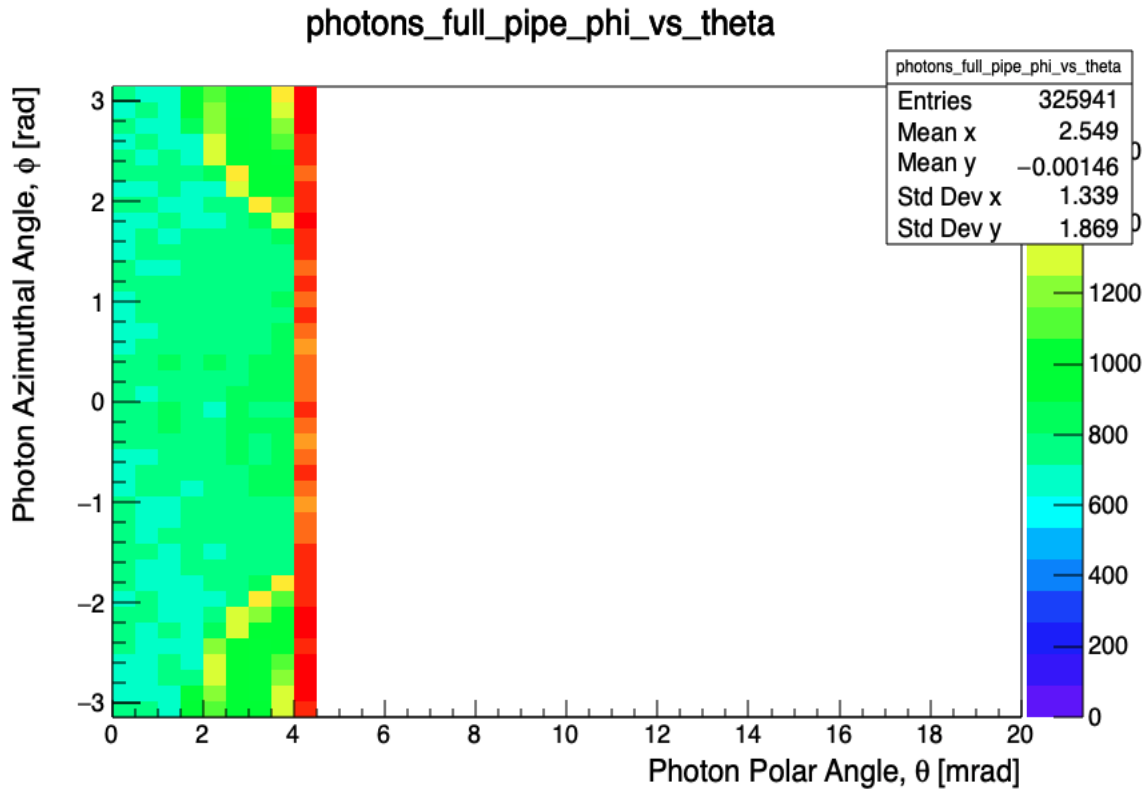


electron_pT_vs_positron_pT_MC

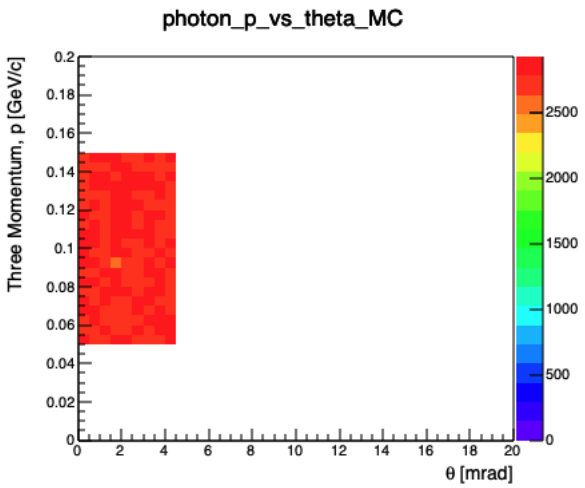


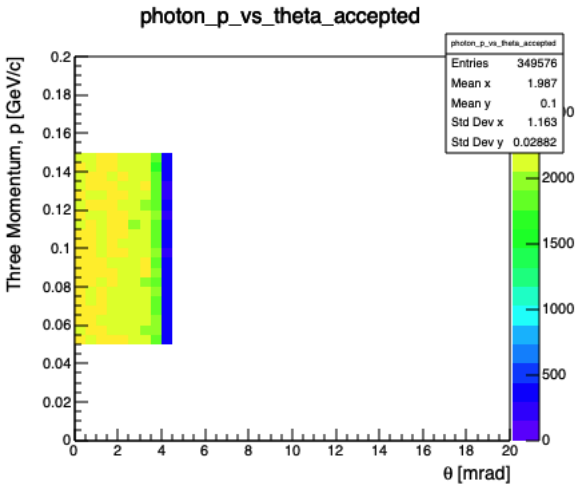
TGeant3 with Aluminum Pipe

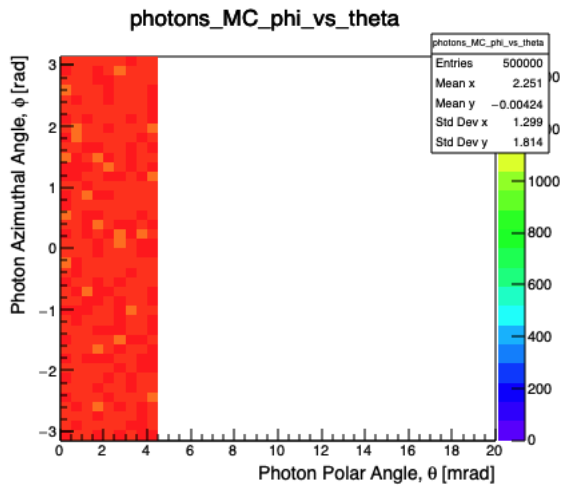


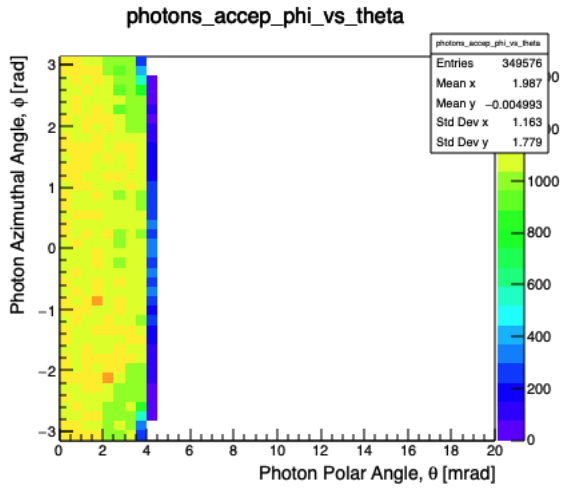


TGeant3 with Beryllium Pipe

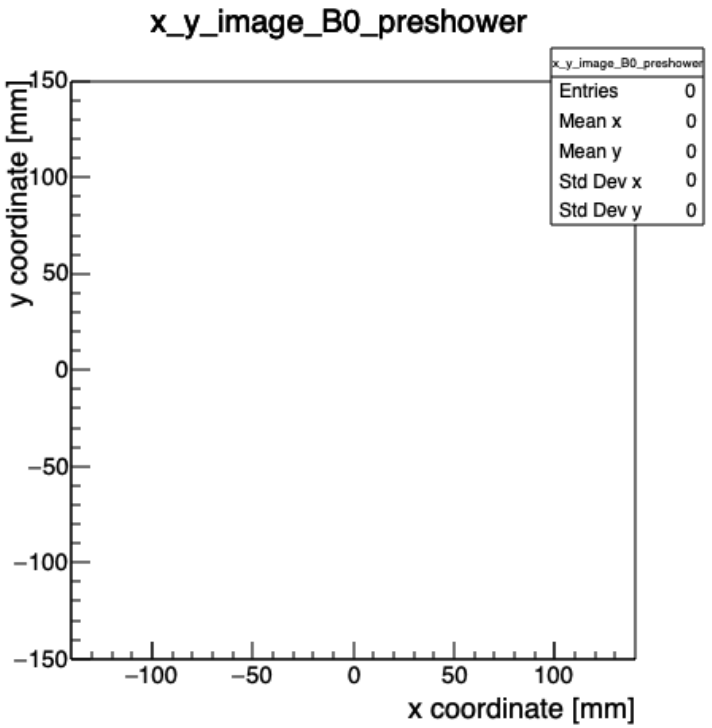


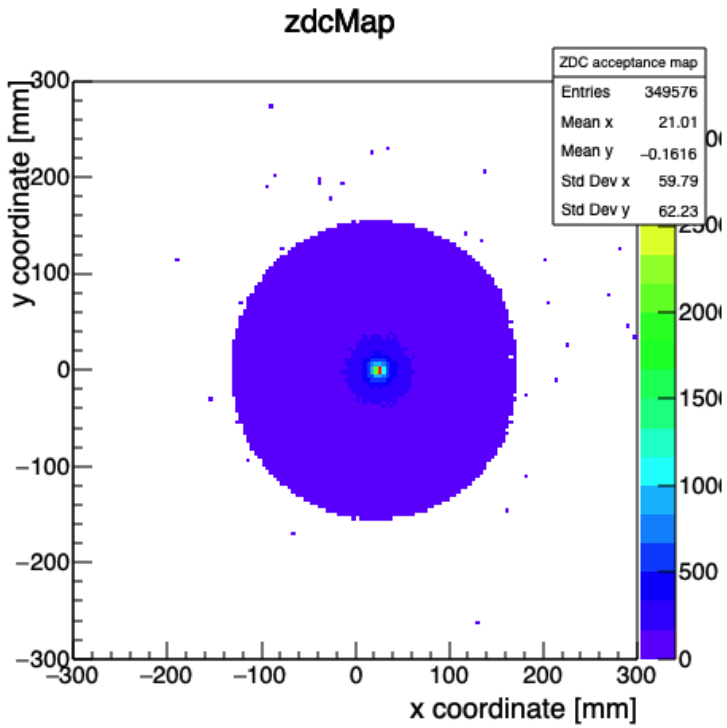






TGeant3 with Beryllium Pipe





Percentage of Photons that Survive:

69.915 percent

_Beryllium beam pipe.

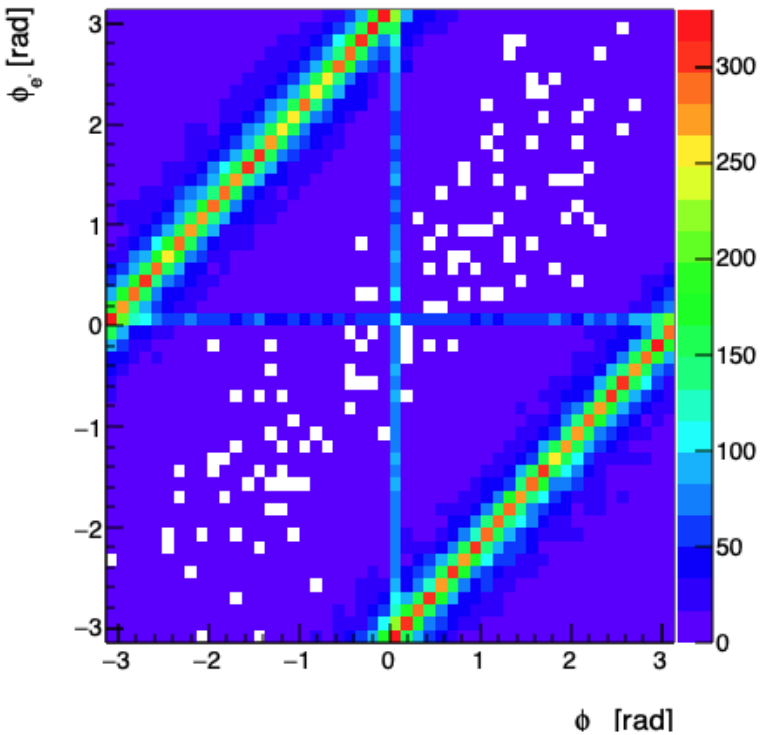
TGeant3 with Beryllium Pipe

Percentage of Photons Produce Single e+e- pair:

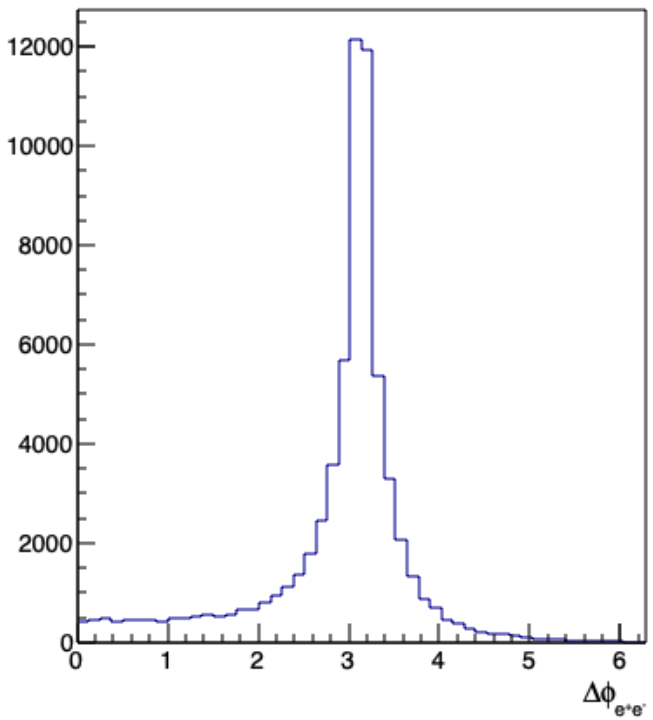
13.130 percent

_Beryllium beam pipe.

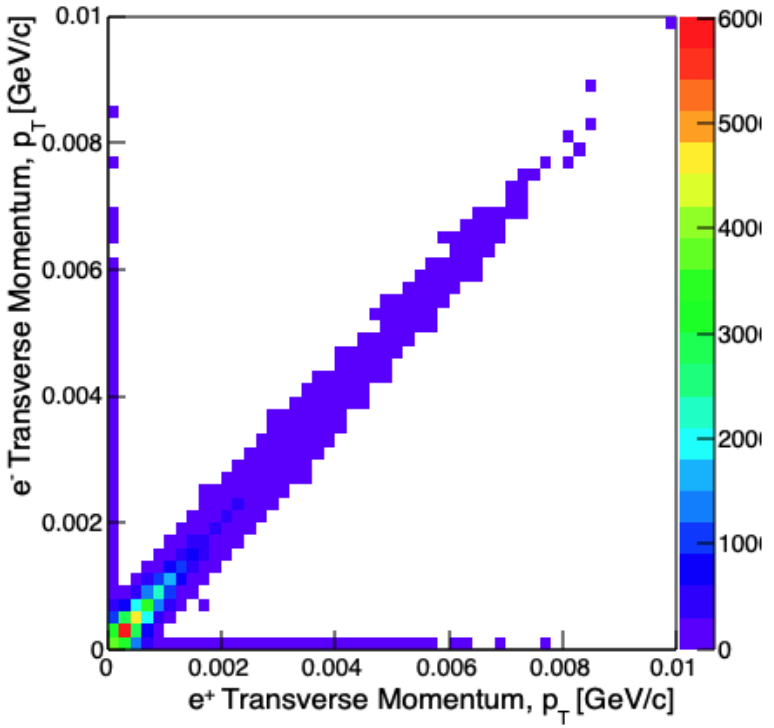
electron_phi_vs_positron_phi



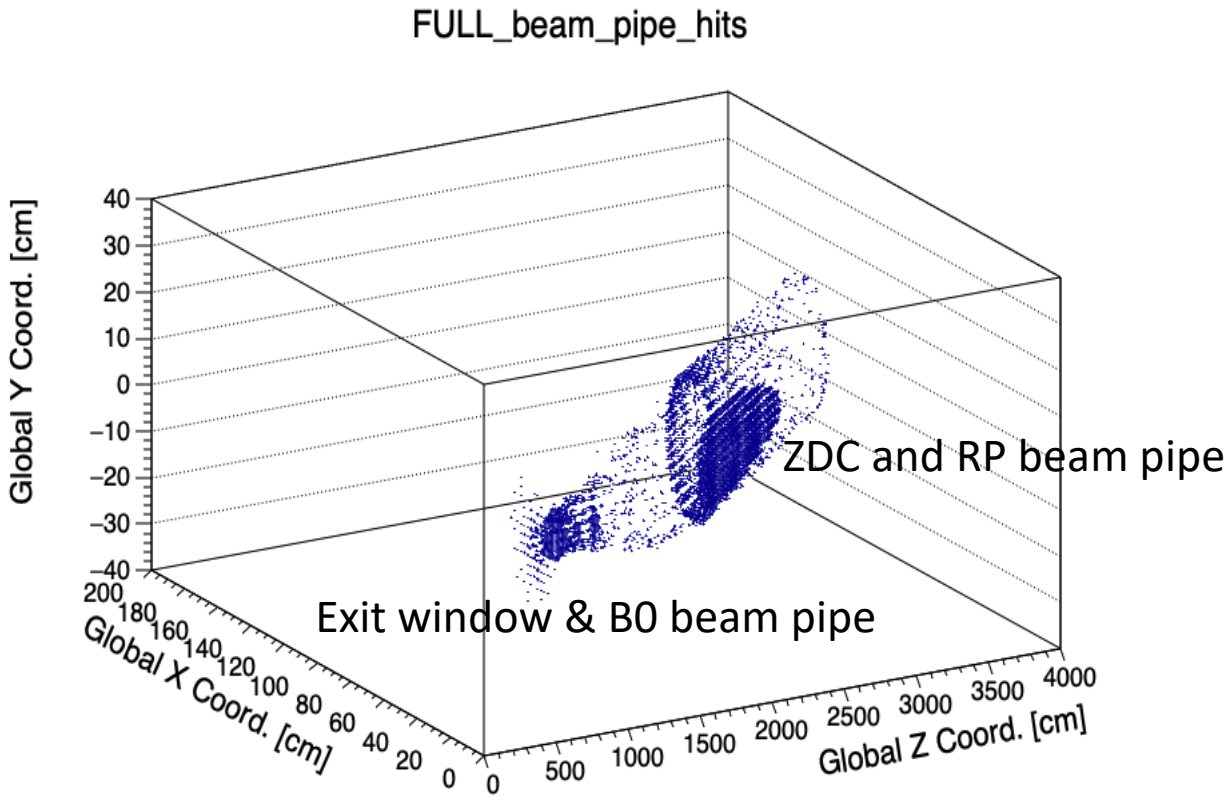
lepton_pair_delta_phi_MC

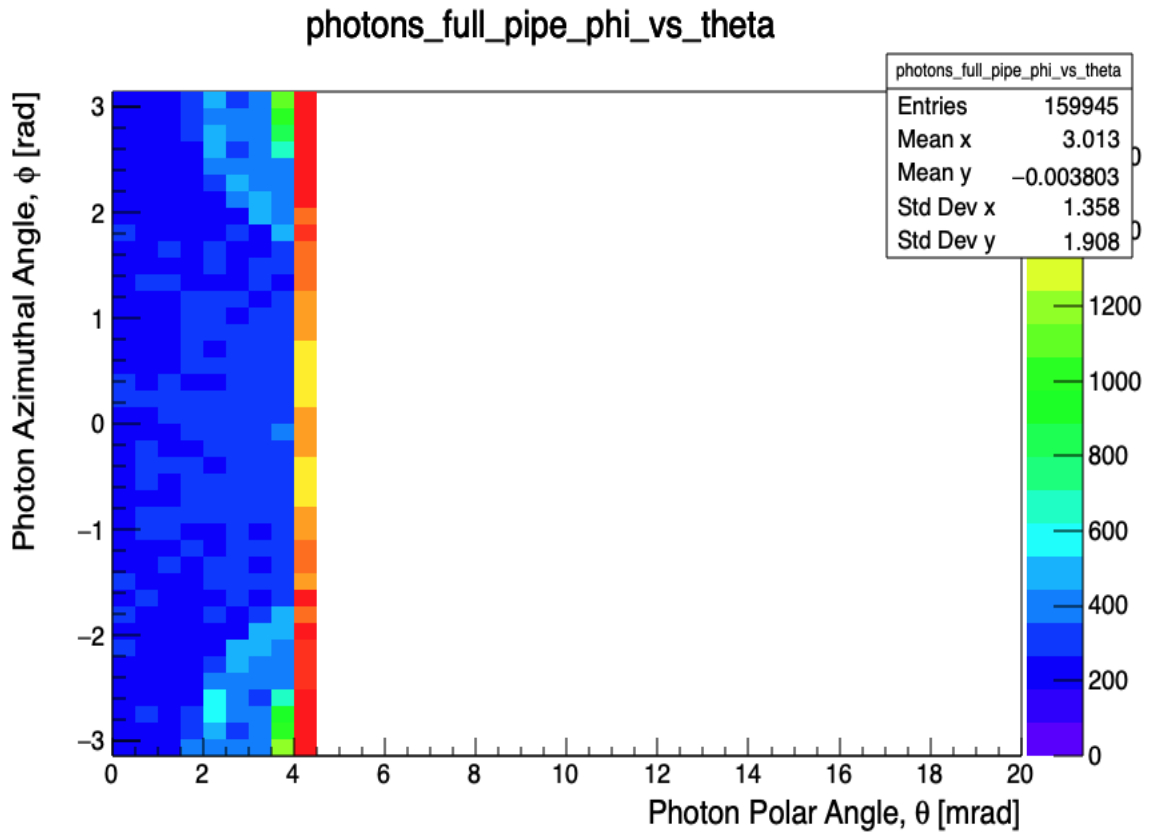


electron_pT_vs_positron_pT_MC



TGeant3 with Beryllium Pipe





What about neutrons?

- Myself and others have very off-handedly discussed putting a Be pipe section where particles exit the lattice after B1apf to go toward the ZDC/Off-Momentum Detectors.
- After *actually* looking into this and not just throwing something out there, the Be option could have a negative impact on our neutron detection.
- Be is highly reflective of neutrons, as the nuclear interaction cross section for neutrons on Be is on the order of several barns.
- It’s used in reactors for this very purpose.
- GEANT does show differences between G3/G4 for the neutron interactions.
  - Still trying to understand where these difference come from.

Summary

- G3 and G4 both give the same results for photon survival probability.
  - The format of the settings between G3 and G4 in the VMC are *not* the same, and seem to have different defaults.
  - Need to tweak a little more to see if I can reproduce the same results between the two (this really should be the goal – it gives better confidence in the overall study).
- If the photons convert via the IP exit window, the resulting pair will likely be un-useful due to strength of B0pf dipole field.
- Using a Be pipe near the ZDC exit region significantly increases the photon survival.
  - BUT this could have a negative impact on neutrons as they have a very high (~ barns) cross section in Be. Needs further study.
- Pairs converted before ZDC still to be studied.